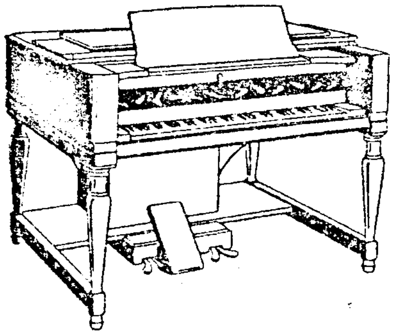
THE HAMMOND NOVACHORD

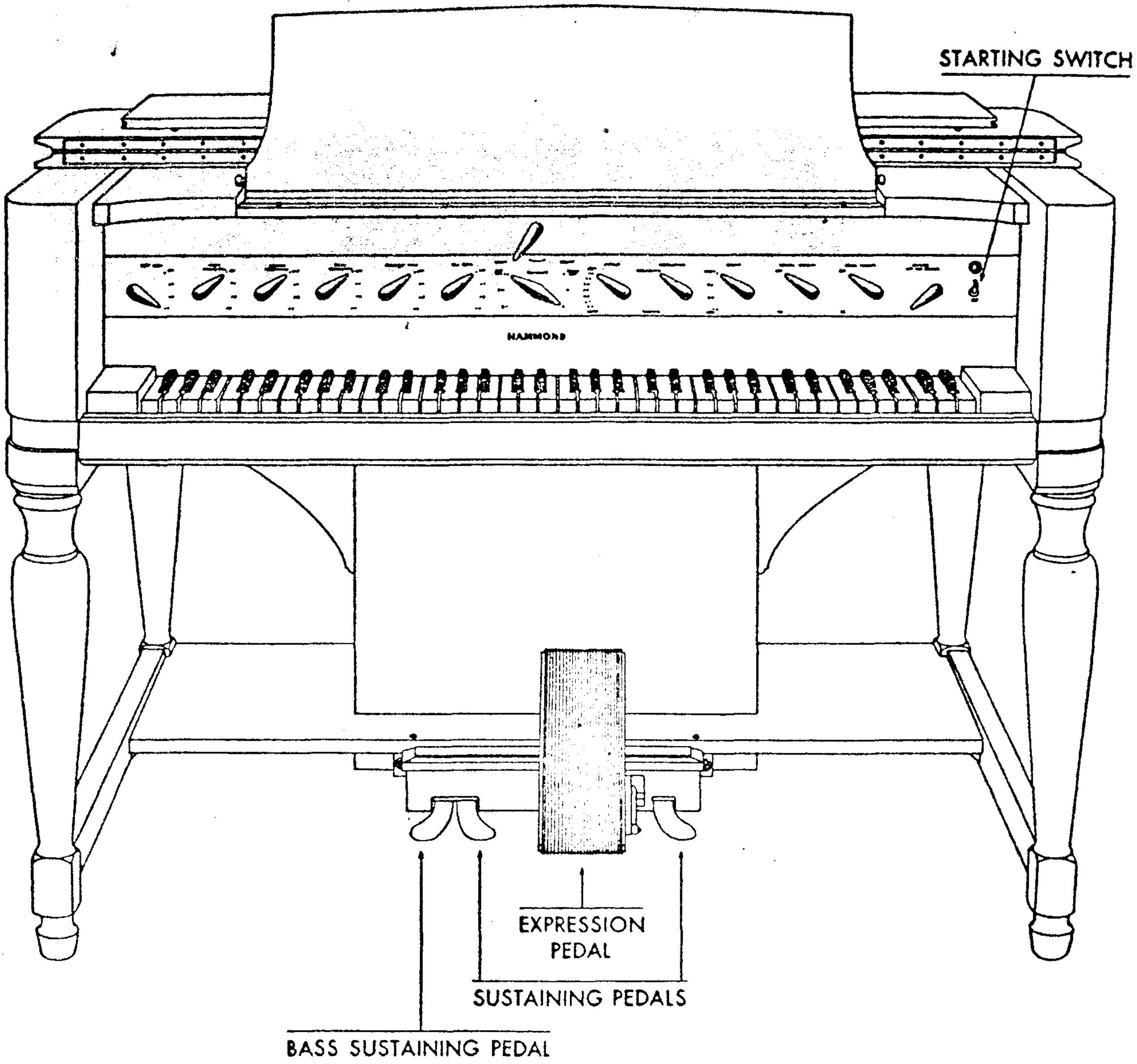
A MANUAL FOR THE SERVICE TECHNICIAN

Second Edition



Hammond Instrument Company
4200 W. Diversey Avenue
Chicago 39, Illinois

1051



THE NOVACHORD

Figure 1

Specifications

Dimensions:		
	Width,	52 1/4 inches
	Depth,	36 3/4 "
	Height (closed)	38 1/4 "
Finish:	American Walnut	
Weight:	500 pounds	Weight packed, 714 pounds
Wattage:	440	

OPERATION OF THE NOVACHORD

The Novachord is unique among musical instruments in that the player may control the "attack", or growth and decay characteristics, of the tones produced in addition to having available a wide range of effective tone qualities.

The control panel immediately above the keyboard, illustrated in figures 2 and 3, contains the various controls affecting the tones of the instrument. Below the keyboard are the sustaining pedals and the expression pedal. (See figure 1.)

STARTING THE NOVACHORD

A single switch at the right end of the control panel turns the instrument on and illuminates a small pilot light.

Allow about thirty seconds after turning on for the vacuum tubes to warm up. Then lift and release the lever marked "Starter". The Novachord is now ready to play.

TONE CONTROLS

The first six controls at the left side of the control panel are the tone controls. "Deep Tone" is a low pass filter which emphasizes the lower frequencies; "First Resonator", "Second Resonator" and "Third Resonator" are tuned circuits which emphasize particular ranges of frequency; "Brilliant Tone" is a high pass filter which emphasizes the higher frequencies; and "Full Tone" passes all frequencies equally.

The tone controls are connected in the output circuit of the tone generator and act on all notes of the instrument. Each has three loudness positions in addition to "Off". When all six are "Off" no sound may be produced by the instrument.

BALANCER

The Balancer, located in the center of the control panel, slightly reduces the volume of the lower half of the keyboard by shunting fixed resistors across the output circuits. In position 3 (strong bass) it is open and has no effect.

BRIGHT-MELLOW CONTROL

This control, located above the Balancer, affects the entire keyboard except the lower 18 notes. In the mellow position it closes switches which reduce the harmonic content of the tone by introducing condensers into the control tube circuits.

ATTACK CONTROL

The tone of the Novachord may be made percussive, with a sharp attack after which the tone gradually dies away, or the tone may be made to have a perceptible period of growth after which it is sustained as long as a key is depressed. These effects are governed by the attack control which is located at the right of the balancer. The attack control has seven positions ranging from "Fast" to "Slow" and operates a multi-contact switch which varies the operating voltage applied to the key circuits.

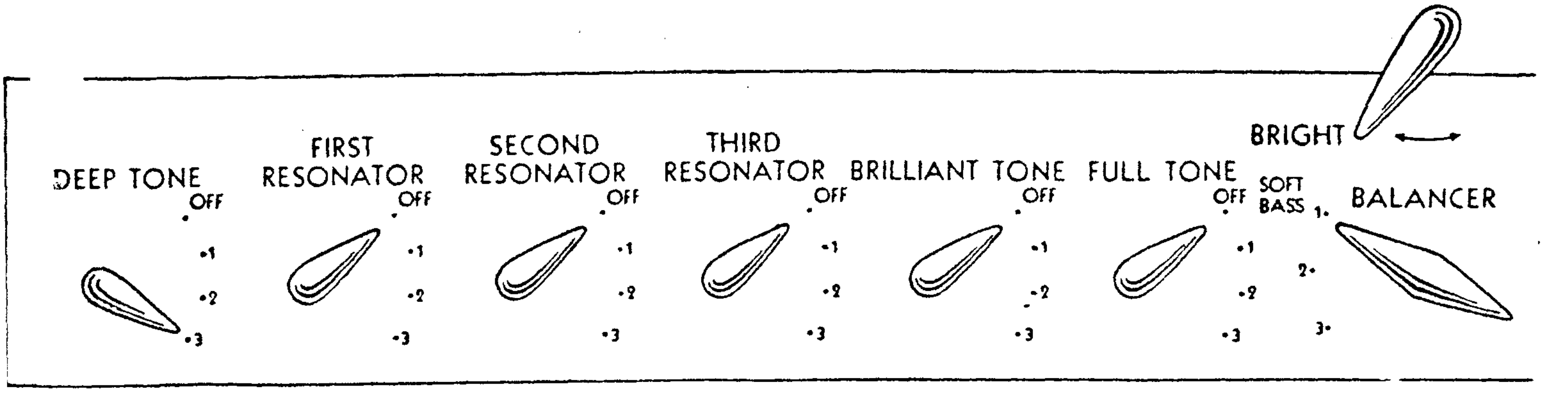


FIGURE 2.

COMBINATION CONTROL

The combination control is a mechanical device which simultaneously moves all controls necessary to obtain two contrasting types of tone most generally used. It has two positions, "Percussion" and "Singing". When the other controls are operated, the combination control in most cases returns to a neutral position half way between its operating positions.

VOLUME CONTROL

This control is supplementary to the expression pedal and serves to limit the maximum volume of the instrument yet preserves the full range of the expression pedal. It has four positions, position 4 being the loudest.

VIBRATO CONTROLS

The vibrato controls introduce a periodic variation in frequency or pitch of all notes. This effect is produced by six vibrating reeds within the instrument. "Normal Vibrato" and "Small Vibrato" controls each introduce a certain amount of this effect. "Normal Vibrato" produces a greater variation than "Small Vibrato", and both may be used together to increase the effect.

VIBRATO STARTER

This device is used to start the motion of the vibrato reeds each time the Novachord is turned on. The reeds will often start themselves, but for reliable operation they must be started manually, after which they are kept in motion by electrical means as long as the instrument is turned on. A gentle lift and release of the lever is sufficient to start the reeds.

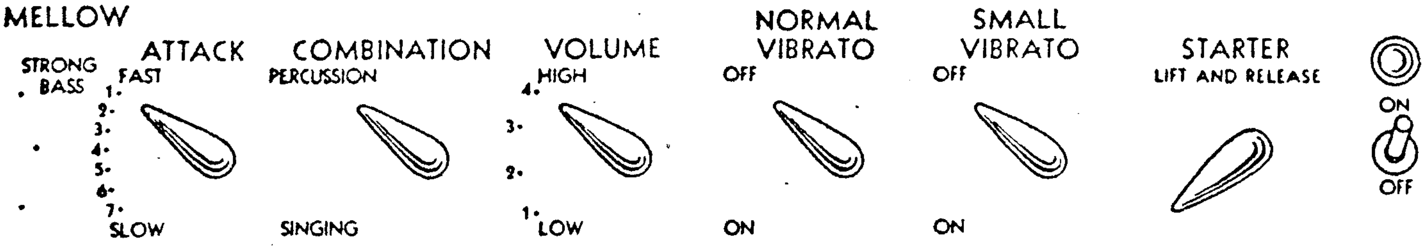


FIGURE 3.

EXPRESSION PEDAL

The expression pedal of the Novachord is similar to the "swell" pedal of an organ and is used to regulate the volume of the instrument. It operates a variable condenser connected in the pre-amplifier circuit.

SUSTAINING PEDALS

The sustaining pedals, located on either side of the expression pedal, are similar in effect to the "damper " pedals on a piano. They cause the tones of the Novachord to sustain after the playing keys are released by removing cut-off bias from the control tubes. The bass sustaining pedal, located at the left, affects only the lower 36 notes of the keyboard, while the other two operate over the entire keyboard. The pedals affecting the entire keyboard are duplicates in order to allow the player the option of using either foot for operation.

USE OF THE CONTROLS

A convenient and quick method for setting the control for a certain tone color is first to move the combination control to either "Percussion" or "Singing", depending on which general effect is desired, and then to adjust the other controls as may be necessary. The setting of the controls to produce a certain tone color may be expressed by a formula such as the following:

$$S\ 303300\ \frac{B}{3}\ 5\ 3\ NV$$

The first letter (P or S) shows the position to which the combination control should be moved; the following six numbers refer to the six tone controls; $\frac{B}{3}$ means that the bright-mellow control is set at "Bright" and the Balancer at 3. The next two numbers refer to the setting of the attack and volume controls (if one of them is to remain as set by the combination control, a dash may be substituted for the number.)

The last letters show the position of the vibrato controls - NV for "Normal Vibrato", SV for "Small Vibrato" and VV for both vibrato controls. If neither vibrato is to be used no designation is necessary.

SCHEME OF OPERATION

The tones of the Novachord originate in vacuum tube oscillator and divider circuits. Figure 12 illustrates the operation of the oscillator and dividers for the six "A" notes of the instrument. There is a similar oscillator and five dividers for each of the other notes of the musical scale. As there are twelve notes in the musical scale, there are twelve oscillators and sixty dividers in the Novachord, or one tone-producing tube for each of the seventy-two playing keys. The twelve oscillators operate at the frequencies of the highest octave of the instrument (F to E inclusive).

Each frequency divider is a non-linear amplifier operating in such a manner that its output signal has half the frequency of its input signal, and therefore the musical interval between two consecutive dividers is one octave. Referring to Figure 12, it may be seen how the dividers are cascaded and thereby supply the different octaves of the note "A".

Associated with each oscillator and with each divider is a control tube which acts as a valve operated by a playing key. There is one control tube for each of the seventy-two playing keys. Signals from the oscillators and dividers are allowed to pass through the control tubes when a playing key is depressed, after which they are modified as to quality in the control box and pass on to the amplification system, which drives two twelve-inch dynamic speakers.

CIRCUIT DIAGRAMS

Figure 13 is a schematic circuit of the entire instrument exclusive of the amplification system and the power supply unit. This diagram shows the oscillator and the vibrato circuit of instruments serial numbered 1700 and above; other circuits, however, are identical in all Novachords. Figures 9 to 23 illustrate in detail typical sections of the Novachord circuits.

The resistor and condenser numbers, such as "RN 4" or "CN 3" are assigned according to their use in the circuit, rather than actual resistance or capacity value, as the actual value may vary from note to note or octave to octave.

OSCILLATOR AND VIBRATO CIRCUIT - NOVACHORD SERIAL NO. 1699 AND BELOW

Figure 14 shows the oscillator and vibrato circuit used in Novachords serial numbered below 1699. The tuning coil has a movable core section actuated by a thumb nut for tuning the instrument. This coil is shunted by two condensers, CN 11 and CN 12, one for rough tuning and one for fine tuning. This is a high Q tuned circuit requiring little feedback voltage and providing excellent stability of operation.

Triode 1 drives triode 2 through a voltage dividing network and also provides a signal through RN 19 to the highest octave control tube. The output of triode 2 is connected through feedback resistor RN 14 to the grid of triode 1 and also provides a signal to the first divider tube.

The vibrato circuit associated with the oscillator periodically varies the oscillator frequency by means of a vibrating reed, magnetically driven, which detunes the circuit slightly at each vibration of the reed. There are six reeds vibrating at different rates, each producing the vibrato effect for two oscillators. Each vibrato switch shown in Figure 14 is part of a twelve gang switch operated by a single control knob.

The small vibrato switch, when closed, connects condenser CN 33 across a portion of the oscillator tuning coil, thus lowering the oscillator frequency, each time the reed contact closes. The mean frequency is slightly lowered from normal, but to such a small degree that it is not objectionable.

The normal vibrato switch similarly connects CN 32 in the oscillator circuit, but in this case the condenser is large enough to lower the mean frequency to an objectionable degree; therefore, the mean frequency is caused to remain normal by removing compensation condenser CN 31 from the circuit when the vibrato switch is closed. The oscillator is, of course, originally tuned with CN 31 in the circuit. The reed contacts, when properly adjusted, are closed one half of the time; therefore, CN 32 is twice the value of CN 31.

OSCILLATOR AND VIBRATO CIRCUIT - NOVACHORD SERIAL NUMBER 1700 AND ABOVE

Figure 15 shows the oscillator and vibrato circuits used in Novachords serial numbered 1700 and above. Triode 1 of the 6C8-G tube is part of a conventional oscillator circuit including tuning coil and condensers CN 11 and CN 12 as tuning constants. Triode 2 operates as an amplifier connected in such a manner as to increase the apparent capacity of condenser CN 17 as the gain of the tube is increased, thereby changing the frequency of the oscillator.

The vibrato reed, by changing the grid bias of triode 2, causes a periodic change in gain to take place. Switches "Small Vibrato" and "Normal Vibrato" bring triode 2 into operation and control the amount of change in gain produced by the vibrato reed. Resistor RN 40 and condenser CN 16 act as a filter to prevent the vibrato reed from making the change in gain in triode 2 too abrupt. This filtering action makes the vibrato effect smoother and more pleasing to the ear.

DIVIDER AND CONTROL CIRCUITS

Figure 16 shows typical divider and control tube circuits.

The type of frequency divider used in the Novachord does not oscillate, but the circuit constants are so chosen that the divider tube responds only to alternate cycles of the input frequency and, therefore, its output has half the frequency of the input. If an oscillator ceases to operate, all the dividers associated with it will also fail to operate. The divider tubes operate continuously. The signal is not heard, however, until the corresponding control tube is caused to function.

Each control tube is normally cut off, and cannot function until the associated playing key is depressed and allows cathode current to flow. In addition to this function of keying the signal, the control tubes modify the wave form of the signal so as to introduce harmonics and enrich the tone. The degree of enrichment thus provided is controlled by the "Bright-Mellow" switch associated with each tube and operated by a single knob on the control panel. The lower eighteen notes of the instrument are not so affected as CN 30 with its associated switch is not used on these notes.

Figure 17 shows the control tube as adapted for use with the oscillators which furnish the signal for the highest octave of the Novachord.

Figure 18 shows the divider circuit as used in the lowest octave of the instrument.

Each frequency divider is a non-linear amplifier operating in such a way that its output has exactly half the frequency of its input signal. A typical divider circuit is shown in Figure 16. Its operation may be roughly described as follows.

The steady-state plate current of the tube, about .2 milliampere, causes a drop across the 1 megohm bias resistor RN 6 of 198 volts. This opposes the -192 volt fixed bias supply and leaves a net bias of about 6 volts on the tube.

Suppose that a signal comes from the preceding divider or oscillator. It is a sharp-pointed wave and suddenly makes the grid go positive. The resulting flow of plate current increases the drop across RN6 and makes the cathode also go suddenly positive. Since the change is very rapid, it acts through CN2 to make the grid more positive, so that the grid remains positive even after the input wave has passed. Whenever the tube is tripped, therefore, it operates until the cathode and plate potentials are so nearly alike that plate current can no longer flow. At this time both cathode and grid are at approximately the same potential (represented by the peak of the wave in Figure 4) and CN3 is charged to a corresponding voltage.

Now the grid and cathode begin to float toward ground. The grid potential (G in Figure 4) goes down at a rate determined by leakage from ground through RN4 and RN13 into CN2 and CN3 in series. The cathode potential (K in Figure 4) goes down at a rate determined by the leakage from -192 volts through RN6 into CN3. The time constants of these two circuits are so adjusted that G floats down faster than K.

Thus, when the second input cycle arrives and raises the grid potential, it still does not go above the cathode and so the tube remains cut off. The shaded part of the curve is the portion where the grid-to-cathode voltage is sufficient to keep the tube cut off. The third input cycle, however, finds the voltage low enough so that it trips the tube and produces another output cycle.

Suppose that the cathode floats down too rapidly, or the grid floats down too slowly. The cathode and grid potentials are then so close together that the second input cycle is able to trip the tube. The tube will now operate on every input cycle, its output will have the same frequency as its input, and the note will play an octave high.

Suppose, on the other hand, that the cathode floats down too slowly, or the grid too fast. The potential difference will then be great enough to make the tube miss not only the second input cycle but the third as well. The tendency is then to divide by three, but a divider of this type does not readily divide by three. Therefore it will miss the fourth input cycle also and thus divide by four.

A divider can theoretically be made to divide by any number, but for uneven numbers and for numbers above four the circuit is unstable. In practice, therefore, only three conditions occur: (1) the note divides by two and plays the right pitch; (2) it divides by four and plays an octave low; or (3) it does not divide at all and plays an octave high. It can be seen by observation of the waves that the change from one condition to another is gradual, so a note that "plays an octave low" is not a pure note of the lower octave but merely has an audible sub-octave component.

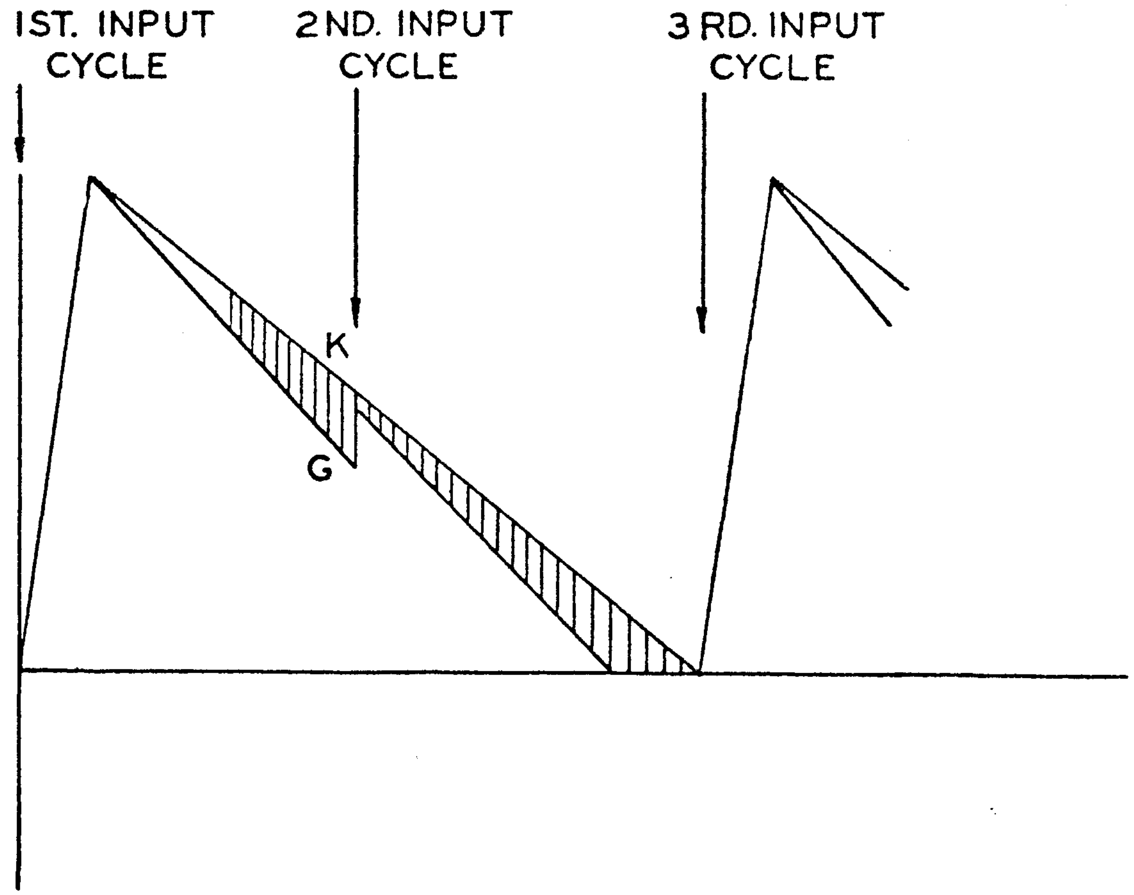


FIGURE 4

PLAYING KEY CIRCUIT

The circuit of a typical playing key is shown in Figure 19 with connections to the "attack" switch. There are three contacts under each key, of which two make contact with bus-bars. Bus-bar "A" extends the length of the keyboard, while the "Cut-off" bus-bar is in four sections, each at a different cut-off potential.

The "attack" switch, located in the control box, varies the potential of bus-bar "A" between ground and -260 volts. The potential of "A" determines the initial intensity of the note when a key is depressed and that of "C" determines its final intensity with the key held down. Therefore, if "A" is at high potential and "C" is at low potential, the attack will be fast or percussive, and the note will start at high level and decay to a low level. With "A" at low potential and "C" at high potential, the note will start at low intensity and build up to a high level. Intermediate positions will give speeds of attack and decay between these extremes. If both "A" and "C" are at the same potential, the note will have constant amplitude and will, therefore, be sustained.

Each control tube is normally prevented from operating by the voltage of the "Cut-off" bus-bar, acting through resistor RN10. When a key is depressed, contact spring 3 leaves the "A" bus-bar and touches spring 2, which is stationary. At the same time spring 1 breaks contact with the "Cut-off" bus-bar.

Before the key is depressed, condenser CN8 is charged to a potential determined by "A" and "C" as adjusted by the "attack" switch.

When spring 3 is moved from the bus-bar to spring 2, this voltage charges CN7. Current then passes from this condenser over the keying lead to the cathode of the control tube, and the note sounds. When the key is released the note will decay rapidly as CN7 discharges through RN10, unless the sustaining pedal is depressed. This pedal opens contact 1 on all keys and makes the decay slower since CN7 can then discharge only through the control tube.

The initial potential of CN8 is determined largely by the voltage "A" since RN12 is much smaller than RN11. With the "attack" switch set at "fast" the potential "A" will be high. If a key is then depressed and held down, the note will sound suddenly, then decay slowly until CN8 approaches the potential of "C". If, on the other hand, the attack switch is at "slow" and "C" is at higher potential than "A", the note will start at low intensity and build up as CN8 charges.

CONTROL BOX

Figure 20 illustrates the control tube output connections to the control box and the resonant circuits in the control box which make available the many different tone colors of the Novachord. Each resonator is tuned to a different audio frequency and is controlled by a variable resistance across it.

The "brilliant" tone, "deep" tone, and "full" tone controls are similarly equipped with variable resistors. These variable resistors are actually switches with fixed resistors, and so are not subject to wear as in the usual type of control.

When any resonator is shorted out by setting its variable resistance at zero, it, of course, has no effect. The "full" tone control may be used alone to provide even frequency response and may also be used to vary the sharpness of tuning of the resonators.

The volume control, a switch connected to a resistance capacity network, supplements the action of the expression pedal. The "Balancer" switch connects fixed resistors across resistors RN23 for the lower half of the keyboard. These reduce the strength of the bass notes.

PRE-AMPLIFIER

The pre-amplifier circuit, illustrated in Figure 21, includes the expression control condenser which is operated by the expression pedal. This condenser is variable and is arranged in a degenerative feed-back circuit so that a reduction in its capacity increases the volume of the instrument.

The volume adjustment condenser is inserted in the pre-amplifier input circuit to set the volume of the Novachord at the proper level before it leaves the factory. (Fixed mica condenser in some units.)

Fixed bias is obtained from the -192 volt divider tube bias supply.

A portion of the power amplifier output signal is fed through a suitable network into the cathode of the 6J5-G tube so as to oppose the cathode signal and thus reduce the hum level.

Radio frequency interference is prevented by a 50,000 ohm resistor in series with the control grid of the 6J7-G tube. The output transformer has a 500 ohm push-pull output.

If the Novachord is to be played through a separate tone cabinet, its own loud speakers may be disconnected by removing the signal wire from the speaker binding post located on top of the pre-amplifier channel. If this signal wire is removed it must always be connected to the other binding post, which is grounded through a 12 ohm resistor, in order to prevent oscillation in the feed-back circuit.

POWER AMPLIFIER

The power amplifier, illustrated in Figure 22, is a standard Hammond Organ amplifier using two type 56 input tubes and four 2A3 tubes in push-pull parallel.

Any standard Hammond Organ tone cabinet may be connected to the Novachord if additional volume is desired. The 5 conductor cable used with these cabinets may be connected to the extra receptacle in the Novachord power amplifier. Only one extra amplifier should be connected in this manner, others being connected to an external source of AC power.

POWER SUPPLY UNIT

The power supply unit is illustrated in Figure 23. This unit furnishes all plate, screen, grid and keying voltages needed in the Novachord and employs an unusual method of filtering using vacuum tubes to take the place of the usual filter condensers.

Rectifier tube A supplies 270 volts between terminals 5 and 9, filtered by tubes B, C, and D. The filtering action of these tubes is as follows.

Suppose a small ripple appears in the 270 volt line. It will be impressed on the cathode of tube B through condensers C32 and will be amplified by tube C. The amplified ripple will then appear across R77 and will drive tube D, which is the actual filter, and the plate current of tube D will change in such a way that it opposes the original ripple in the line and cancels it out. Any high frequency ripple the oscillators may introduce into the power supply is also filtered out by this system.

Tubes E, F and G operate similarly for the 70 volt tap on the voltage divider network. The portion of this voltage divider between terminals 6 and 5 is located in the keyboard and is shown in Figure 20.

Rectifier tube J supplies 260 volts for keying. Tube I furnishes 192 volts bias for the dividers and the preamplifier, while tube [illegible] supplies 50 volts to the vibrato driving coils.

A 10 wire cable connects the power pack to the generator terminal panel. Terminal 10 of the 11 pole plug is connected to a shield on the two 260 volt wires.

THE NOVACHORD CONSOLE ASSEMBLY

The Novachord console contains four major assemblies: the generator and control box assembly, power supply unit and power amplifier. All of these assemblies are easily accessible for servicing.

A card giving instructions for installing and preparing the Novachord for use and outlining simple maintenance procedure will be found attached to the under side of the hinged top section of the console case.

The generator assembly includes the oscillator, divider and control tubes and their respective circuit components, control box and panel, vibrato mechanism and pre-amplifier.

The keyboard chassis assembly includes the playing keys and contacts with their mounting parts and also the channels containing the condensers and resistors for the playing key circuits.

GENERATOR ASSEMBLY

The top of the generator is accessible by opening the top section of the console case. This case top is hinged at one end and fastened to the case bottom at the opposite end by a knurl head screw. When open, the case top is held in position by a canvas strap.

Figure 7 shows the layout of the top of the generator. The generator is divided into nine "channels" mounted on steel angles. Each of the first five channels includes divider and control tubes for one octave; the sixth contains control tubes only for the top octave; the seventh is the oscillator channel; and the eighth and ninth contain the vibrato and pre-amplifier respectively.

Each of the first seven channels has a hinged cover. The hinge rods are notched to form switches and are coupled to the "Bright-Mellow" control. Condensers and resistors are mounted on the inside of some of the covers. (See Figures 10 and 11). Additional condensers and resistors are mounted beneath the channels.

The control box, in front of the channels, contains switches and associated components for the resonators, balancer, attack control, volume control, and a mechanism for the combination control. The control box is held in place by three screws at each end and two in the center.

The vibrato reeds are accessible for adjustment by removing a cover located near the rear of the vibrato channel. This cover is held in place by three metal straps screwed to the top of the assembly. The front section of the vibrato channel contains the vibrato control switches.

The pre-amplifier channel contains, in addition to the pre-amplifier, a heater transformer which furnishes current for heaters of all tubes in the generator.

The under side of the generator may be reached as follows:

1. Turn the instrument off. Remove generator clamping bolts, one in center of each end block.

2. On each side of the generator is a lag screw which fits in a slot in the metal guide rail. Lift each end of the generator enough to move the lag screw from the slot to the depression in the rail just in front of the slot.

3. Slide the generator forward as far as it will go. It will stop when the screws in the end strike the guide rails. Be sure that generator is as far forward as it will go.

4. Lift the front of the generator until it stands vertically on the back of the wood end blocks. The connecting cables will bend and the coil springs which connect the control circuits with the keyboard will stretch enough to allow this movement. The instrument may be operated with the generator in this position.

Figures 8 to 11 inclusive show the location of condensers and resistors in the oscillator, divider and control channels of the generator. The numbers used to identify these circuit components correspond to the numbers used in the circuit diagrams (Figures 14 to 21).

KEYBOARD CHASSIS ASSEMBLY

The 72 keys of the Novachord are molded from Bakelite and Plaskon and mounted on metal channels. Key tension is provided by flat springs. Contact actuators are mounted on the key channels and are adjustable by means of set screws. The keys, contacts and associated mounting parts comprise the keyboard assembly.

The keyboard chassis assembly includes the keyboard assembly and the two condenser channels mounted on the wood end blocks. These channels contain the condensers and resistors associated with the key circuits.

Condensers CN8 and resistors RN11, RN12, RN33, RN37 and RN38 are mounted on the top of the assembly and are accessible when the generator is in a vertical position. CN7 and RN10 are mounted on the under side of the channels.

To remove keyboard chassis assembly and reach CN7 and RN 10 proceed as follows:

1. Remove four bolts which fasten chassis to case bottom.

2. Loosen steel tape connection to sustaining pedal at back of left end of keyboard chassis.

3. Remove two screws holding keyboard to the middle of wood front rail.

4. The keyboard chassis may now be lifted and tipped back to rest against the under side of generator. Be careful in lifting the keyboard so that the cable clamp at the bottom end of the generator does not cut into the keyboard wiring.

When replacing the keyboard chassis, be sure that there is no visible opening between the chassis and the wood front rail. The sustaining pedal adjustment will not be correct if there is an opening.

POWER SUPPLY UNIT

The power supply unit is spring mounted on the upper shelf located at the back of the instrument. It may be removed for replacement or service by withdrawing cable connections and removing a rubber bushed retainer at each end of the unit.

Fibre washers are inserted beneath the two rear mounting springs so that the unit is supported in a level position. If these washers are removed, they should be replaced in original position. One thick and one thin washer goes under the left rear spring and one thick washer goes under the right rear spring. The two front springs do not require any washers.

POWER AMPLIFIER

The power amplifier is mounted on the lower shelf at the back of the instrument in the same manner as the power supply unit. It may be removed in the same manner as the power supply unit.

ANALYSIS OF TROUBLES

rvicing the Novachord need not be unusually difficult. If adequate tools, correct replacement parts, and a logical, methodical approach are used, the large majority of repairs may be made easily and quickly, with the assurance that the instrument will give excellent service. On the other hand, a hit or miss procedure is sure to result in loss of time, needless replacement of parts, and unnecessary repeat calls.

EQUIPMENT

In addition to the usual tools carried by the serviceman, an oscilloscope is indispensable when working on divider circuits. A pair of crystal headphones, in series with a 2 megohm resistor and a .01 mfd. blocking condenser, will also be useful. However, whenever headphones are called for in this manual, the oscilloscope may be substituted. An accurate ohmmeter reading to at least 5 megohms is necessary, as is a multi-range voltmeter with a resistance of 1,000 ohms per volt or higher. Voltage readings given are based on a 1,000 ohms per volt meter. A stock of repair parts, at least equivalent to Novachord Parts Kit Number 2, available from the Hammond Instrument Company, must be on hand.

PROCEDURE

The information on the following pages is arranged according to the part of the Novachord to which the symptoms or service operations listed in the sub-headings relate. A step by step method of repair should be llowed. If the instrument does not operate at all, the trouble is probably in the power or amplification circuits, and this must naturally be corrected first. Then, any trouble common to all notes should be repaired before attempting to work on troubles with individual notes. From this point on, a "top to bottom" order should be observed. If any work on oscillators appears to be necessary, including tuning, it should be done before working on divider or control tube circuits, except as necessary to make the tuning possible. Next, the highest note which is not operating properly should be repaired. If the difficulty with this note happens to be in its divider circuit, correcting this one note will probably correct all of its lower octaves, which would also have been operating incorrectly. Thus, in this and other ways the "top to bottom" method saves time and confusion and always results in a more satisfactory job.

TUBE TROUBLES

In order to avoid the needless repetition of elementary material, all service information in this manual assumes that the Novachord is equipped with good tubes and that all are lighting. Special care must be taken to be sure that the tube involved in the particular circuit being worked on is normal. Substitution of a tube known to be good - from a similar circuit that is operating properly, for example - is recommended. In special cases, additional suggestions regarding tubes are included where appropriate.

I. - CONTROL AND POWER SUPPLY CIRCUITS

All preceding general information, particularly the introduction to this section, should be read and understood before studying the following material or attempting to repair the Novachord.

1. Symptom - no notes sound.

a. See that all tubes are lighted. Turn all resonators to position 3. Move the attack switch to "fast" and then to "slow". If the instrument fails to operate in either position, remove the shield cap from the preamplifier 6J7G tube and touch the grid cap on the tube. A loud hum indicates that the preamplifier and power amplifier are operating.

Should no hum result when the grid cap is touched, remove one of the power amplifier 56 tubes. A loud click indicates that the power amplifier is operating and thus the preamplifier must be at fault.

The absence of a click when the tube is removed suggests trouble in the power amplifier or loud speakers. Be sure the voice coil terminal wire on top of the preamplifier is on the front terminal, otherwise the speakers are disconnected.

Next check voltages at the generator power terminals. Individual voltages should not vary by more than 10% from those indicated on the card beside the terminal panel. For a copy of this see Figure 24. However, all voltages may vary as much as 15%, provided that all variations are in the same direction. If a voltage is low or absent, check the power pack (Figure 23) and the cable leading to it.

b. When all notes fail to play only with the attack control set at "fast", the trouble is probably in the "A" keying voltage supply. This voltage should be -270 volts with respect to ground when the attack control is at "fast".

c. If all notes fail to play only for "slow" attack, the "C" keying voltage is probably absent. This voltage appears between ground and a metal soldering strip at the back of the rear channel on the keyboard. It should be -270 with the attack control at "slow".

d. The following table shows approximate DC voltages for various attack control positions. Both "A" and "C" voltages are conveniently measured at the top end of the cutoff divider resistor panel located at the upper right end of the keyboard assembly. "C" is connected to the left solder lug and "A" to the middle solder lug.

ATTACK SWITCH POSITION	A	C
1	268	9
2	-235	-24
3	-180	-40
4	-125	-125
5	-40	-180
6	-24	-235
7	9	-268

These voltages may vary from 10 to 15 per cent.

If the voltage differs widely from the above table, remove the control box panel and check the contacts of the attack switch. Should trouble occur at "slow" attack make sure that the "C" voltage appears at all points along the common bus bar at the back end of the keyboard condenser and resistor channel.

2. Symptom - One note, notes not related by octaves, or notes related by octaves but not including lowest octave of note, fail to sound. If note in lowest octave fails to sound, see also Section II - 1.

a. A test should first be made to determine whether the note is dead on both "fast" and "slow" settings of the attack switch. If it sounds on either one, the divider and control tubes are both operating, and the trouble is probably in the keying circuit.

If a note sounds with the switch on "fast" but not on "slow", RN11 is open or there is a loose connection to the "C" potential. If a note sounds on "slow" but not on "fast" CN8 may be open or a key contact may be dirty. The latter trouble is corrected by moving the bus bar slightly. This may be accomplished by moving a small lever beneath the right end of the keyboard.

b. Should the note fail to sound on either "slow" or "fast" attack, see that all coil springs connecting the keyboard to the generator are in place. Now remove the spring for the note in question and ground the corresponding generator terminal. The note should sound softly. Ground adjacent terminals and compare loudness of the signal. If the note sounds, the control tube is operating and the trouble is probably in RN9 or RN12.

If the note does not sound with its terminal grounded, try grounding the cathode terminal of the control tube through a 100,000 ohm resistor. The note should then sound at moderate intensity. If it does, RN7 may be open or disconnected. If it does not sound see that there are no loose connections on the control tube socket. If the note still fails to sound, ground one terminal of a set of ear phones and connect the other side to the control tube grid cap. A moderately loud signal of the correct pitch should be heard. Listen to adjacent tubes for comparison.

If no signal is heard, see if the control grid is grounded. Next, check for the signal at the divider cathode. If the signal appear here, but not at the control tube grid, RN1 or CN5 must be open. If the signal is present at the control grid, see that the proper screen potential, about 25 volts, is present. The voltage at the plate terminal varies from about 200 volts on the lower notes to 150 volts on the higher. Comparison with other stages, as described in Section II - 1 - b, is helpful.

c. If the note which does not sound is in the lowest octave, the cause may be in either control or divider circuits. The trouble may be isolated quickly by checking with headphones for a signal of proper pitch and intensity at the cathode of the divider tube. If the correct signal is present, the divider is working and the trouble is in the control circuits. If not, the divider is at fault and should be checked as described in Section II - 1 - b.

3. Symptom - One note sounds continuously.

a. If any one note sounds continuously at low volume, disconnect the corresponding generator-to-keyboard coil spring. If the note no longer sounds, look for a ground in the key circuit. If it still sounds, the keyboard end of RN7 may be grounded.

b. A note which sounds at full volume continuously may be similarly checked. If it stops sounding when the coil spring is removed, key springs 2 and 3 are probably making permanent contact. If it fails to stop, CN15 may be shorted or the control tube cathode may be otherwise grounded.

4. Symptom - Four notes fail to sound.

If four consecutive notes fail to sound, the trouble is probably in the common plate lead to the control tubes of the four notes or in the output network (in the control box) common to these notes.

5. Symptom - Hum or rattles.

a. A mechanical hum or rattle is usually traceable to a warped or torn speaker cone or to loose parts near the speakers. A damaged cone will require that the speaker be exchanged or the speaker head (cone and frame assembly) be replaced with a new one.

b. If an objectionable 120 cycle hum is heard in the speakers, it may be due to a 6J7G tube with loose elements. The heater transformer mounted at the end of the preamplifier channel may set up a mechanical vibration of these elements. Replacing the tube will correct this condition.

c. A warm-up hum or noise occurring when the instrument is first turned on indicates that the emission from the 5V4G tube in the power pack is low. Replace with a new tube to overcome it.

1. Symptom - Two or more octaves, including the lowest, of a note do not sound.

a. Since each divider operates on the signal from the next higher octave, failure of an oscillator or divider will prevent all lower octaves of that note from operating properly. Thus, if several octaves of a note, including the lowest, are wholly or partially inoperative, the trouble is probably in the highest divider that is not normal, or in the oscillator, if no octave of a note sounds. If the lowest octave of a note plays normally, it is apparent that all dividers for that note are operating and failure of notes to sound is due to control tube circuits. See Section I - 2.

b. Repairing oscillator and divider circuits is accomplished most readily by means of the comparison of a defective stage with one that is operating normally. Thus, comparing, by means of an oscilloscope, the wave shape and amplitude of a signal at corresponding points in two oscillator or divider stages will quickly show where the signal deviates from normal. Also, DC voltages may be compared in a similar manner with a voltmeter. Care should be taken in this comparison method to be sure that the stage taken as a standard is really working at peak performance, and is not on the verge of failure, itself. Comparison of several stages should eliminate this possibility. Determination of the particular part at fault may be made by the customary means, that is, measurement or substitution. Short circuits to ground sometimes occur and may be found with an ohmmeter. If it has been necessary to repair an oscillator, be sure to check the tuning. See Section II - 3.

c. If only the top octave operates, and at the wrong frequency, check the oscillator as above, with special attention to the tuning coil and condensers.

2. Symptom - One or more octaves of a note sound an octave high or low.

IMPORTANT

The following information should be studied very carefully. Failure to understand and follow the procedures outlined here is sure to result in failure to effect a satisfactory repair.

a. It is in dealing with complaints of this nature that the "top to bottom" method of working is vitally important. It cannot be emphasized too strongly that while a note may play the wrong octave, generally too high, the trouble may very well be originating in a higher divider stage or in the oscillator. A stage may divide properly but be somewhat low in output. This lack of output may be inaudible, but it can cause a lower stage to be difficult or impossible to adjust.

b. The general scheme for locating defective parts is the same as described in Section II - 1 - a and b. However, special attention must be given to what might appear to be negligibly small variations in amplitude and wave shape. For example, if the lowest octave of a note fails to divide properly, the first thing to check is not the circuit components of this stage, but, by means of an oscilloscope, the output of the oscillator for that note. If comparison with the oscillators for notes that are operating perfectly shows that this oscillator is normal, check the output of the first divider by the same method, and so on down to the point where a deviation from normal output is noted. When this point is found, necessary repairs should be made before proceeding to the next lower stage. In many cases, it will be found that no repairs are necessary on the lower octave which had seemed to be out of order, although adjustment of the lower octave dividers of the note should be carefully checked in any case.

c. The wave shape of the output of a properly operating divider will be quite similar to that shown below.

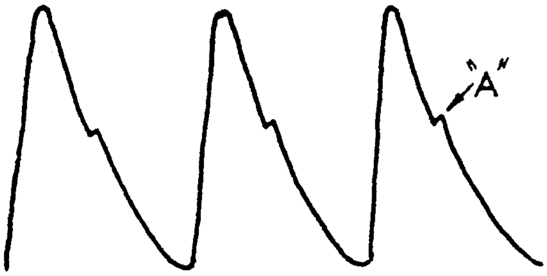


FIGURE 5.

The harmonic indicated at "A" should be as small as possible, and in the ideal case may be eliminated entirely. The comparison method outlined earlier will serve as a guide to the patterns obtained with dividers in various states of adjustment. When it is necessary to work on a divider, an oscilloscope test of the other dividers should also be made in order to detect and correct any approaching trouble in other stages.

d. If a note sounds an octave high at approximately normal volume, CN4 of the previous divider may have increased in capacity. This does not necessarily cause the previous stage to divide incorrectly, but decreases its output, causing the following stage to divide poorly. It has been found that over a period of years the capacity of the condensers tends to increase, in some cases considerably, so this possibility should be investigated carefully. Cathode condensers CN3 may be open or adjustment resistor RN13 may need checking. See Section II - 3 before changing adjustment resistors. Check cathode resistor RN6 carefully for increase in value.

If a note sounds an octave high at low volume, the cathode resistor RN6, grid condenser CN2, or the suppressor lead may be open.

If a note sounds an octave lower than it should, RN 4 or the adjustment resistor may be open or of the wrong value. Resistors tend to increase in resistance, so care should be taken to measure them with an accurate ohmmeter. Also, improving the operation of a higher octave stage may have so increased the signal applied to a divider that the adjustment resistor needs to be changed to one of lower resistance. See Section II - 3.

3. Selecting adjustment resistors.

a. To some extent, it is possible to adjust dividers that tend to sound an octave high or low by means of the adjustment resistors RN13, held in clips under the hinged covers on top of the generator. Experience has shown, however, that when it becomes necessary to change an adjustment resistor there is usually some condition, generally in a higher octave, that needs correcting. With a properly serviced Novachord, it should be possible to set a divider in the middle of its range of normal operation with an adjustment resistor of 1.7 to 2.5 megohms. The value used will depend on the values of resistors and condensers and tube characteristics in higher octaves, all of which may be within tolerances but all tending to produce either a strong or weak signal, with a cumulative effect on the low octaves. Also, RN4, which is in parallel with the adjustment resistor, may be at one or the other of the extremes of its tolerance. It may occasionally be found, therefore, that unusually low, to 1.2 megohms, or high, to 3.5 megohms, values may be necessary in an instrument that is otherwise normal. When, after carefully considering the preceding information, it is decided to change a divider resistor - after repairs on a divider have been made, for example - all dividers, including the highest octave should be checked, regardless of which divider is thought to be the one that requires adjustment.

b. The object in selecting an adjustment resistor is to find the value which places the divider in the center of its range of correct division. No resistor, or one of a high value, will produce a tendency to sound an octave too low; a low resistor, a tendency to sound an octave too high. Some place in between is the best value. The table in Figure 7 is designed to help make the selection, although a certain amount of experience will make it unnecessary to use it.

First, remove the resistor from the clips in the tube compartment for the note being checked in its highest octave divider, channel #5. Sound the note and determine whether it plays "OK" or low. Then install a 3.5 megohm resistor in the clips and observe as before. Make this test with each resistance value in the top line of the chart. Next, look in the chart for the horizontal line that describes the results noted in the tests. At the right of the chart on this line will be found the resistor to be installed in the clips, in the column headed "Channels 4 and 5". Repeat this procedure for each lower octave of the note, in succession, through the lowest. When channels 1, 2, and 3 are adjusted, the resistors shown in the column headed by these numbers are used.

If a divider is found whose performance in relation to the adjustment resistor used is not described on any line of the chart, this or a higher divider is not operating properly and should be repaired before going further. For example, if a divider is found that sounds an octave high with a 2 megohm resistor in the clips, this condition will not be found in the chart, indicating that a repair is in order. See Section II - 2, especially part d.

c. When playing single notes at high amplitude and with both vibrato switches on, there may be slight clicks with the vibrato. This condition is normal. However, a note which is close to playing the wrong octave may click loudly or "warble" when vibrato is used. The dividers for the note should be checked and repaired.

d. For convenience in selecting divider resistors, it is suggested that the serviceman assemble a set of the seven adjustment resistors on a rotary switch, mounted suitably and equipped with short clip leads.

4. Tuning the Novachord.

a. Complete instructions for tuning accompany the tuning kits furnished by the factory. Be sure to use the correct kit, as there are two, one for Novachords serial number 1700 and above, and one for those with lower serial numbers.

b. If an oscillator will not tune to the correct pitch, be sure that vibrato compensating condenser CN31 is good and that the grounding contact associated with this condenser in the Normal Vibrato switch is closed in the off position. This may be checked by sounding the note to be tuned and turning the Normal Vibrato switch off and on. The average pitch, with and without vibrato, should be the same. If the pitch rises with vibrato off, CN31 or the switch is open and repairs should be made. The vibrato must be working normally for this test to be valid. See Section III - 2.

c. If the vibrato circuit is normal and the oscillator is normal in all other respects, but will not tune properly, a change in the value of condenser CN11, in parallel with the main condenser CN12, is necessary. CN11 is selected at the factory for each individual instrument and has no standard value. In early models, it is located near the oscillator tube grid cap and in later models is under the chassis.

In order to select the proper replacement condenser, CN11 should be removed, and a condenser decade box substituted. The knob on the oscillator tuning coil should be turned in approximately one turn. Various values should be tried until one is obtained which will tune the oscillator to the correct frequency. It may be necessary to vary the knob slightly when a value is reached close to the proper frequency. By comparison of the decade box reading and the condenser pan number chart, supplied with this manual, the proper condenser can be inserted.

It should be possible to tune the Novachord using the knurled knob in the oscillator section without exceeding one and one-half turns of the knob from the point where it can be felt to 'take hold', after having been completely loosened.

III. MISCELLANEOUS

1. Mechanical adjustments

a. Key contacts associated with the keyboard may be adjusted. Contact actuators are mounted on the key channels and are adjusted by set screws on top of the key channels.

b. The sustaining pedal may be adjusted by removing the two wood screws holding the wood block at the left end of the keyboard. Adjustment is made by loosening the nut visible from above. Before changing this adjustment, make sure there is no visible opening between the keyboard chassis and the wood front rail.

c. Particles of dust or other foreign material may impair operation of the key contacts. Repeated striking of the offending key should free the contacts. If this does not help, move the bus bar shifter which is plainly visible under the right end of the keyboard. Should it be desirable to wipe the contacts, move the shifter without depressing any keys.

d. The vibrato reeds are also adjustable. There are three contacts on each reed equipped with adjusting screws. The middle contact is for driving the reed. Should the reed fail to operate, this middle contact is probably out of adjustment. The contacts should make in the middle of the reed's motion.

2. Vibrato

The operation of the vibrato is described in detail in the introductory section of this manual. Servicing of these circuits in Novachords below serial number 1700 is a matter of checking the operation of the reeds, the normal and small vibrato switches, and the condensers associated with these switches. In later models, there are also resistors which must be checked. In these instruments, the operation of the vibrato section of the oscillator tube is readily determined by the comparison method recommended in Section II - 1 - b.

3. Troubles due to high humidity

The Novachord employs many circuit elements such as resistors and condensers which may change in electrical value with absorption of moisture. Some of these parts are in relatively critical circuit applications where changes in value will adversely affect the operation of the instrument. In instances where humidity trouble is experienced we suggest the following corrective procedure:

a. Install strip heater inside generator compartment. (See Figure 25.) Heater kits may be obtained from the factory. All Novachords located in humid climates should be equipped with heaters, and instruments which are not used frequently should be heater equipped. These heaters are connected so they are on at all times, producing enough heat to keep excessive moisture out of the instrument.

b. Dry the instrument out thoroughly. In the winter time in temperate or cold climates this can be accomplished by placing the generator in a steam heated room for a period of several weeks. Another method is to leave the instrument turned on for several days so the heat from the vacuum tubes will drive moisture out.

c. Replace parts in oscillator or divider circuits which are causing the immediate trouble.

d. Now check circuits again for proper operation, changing divider resistors if necessary.

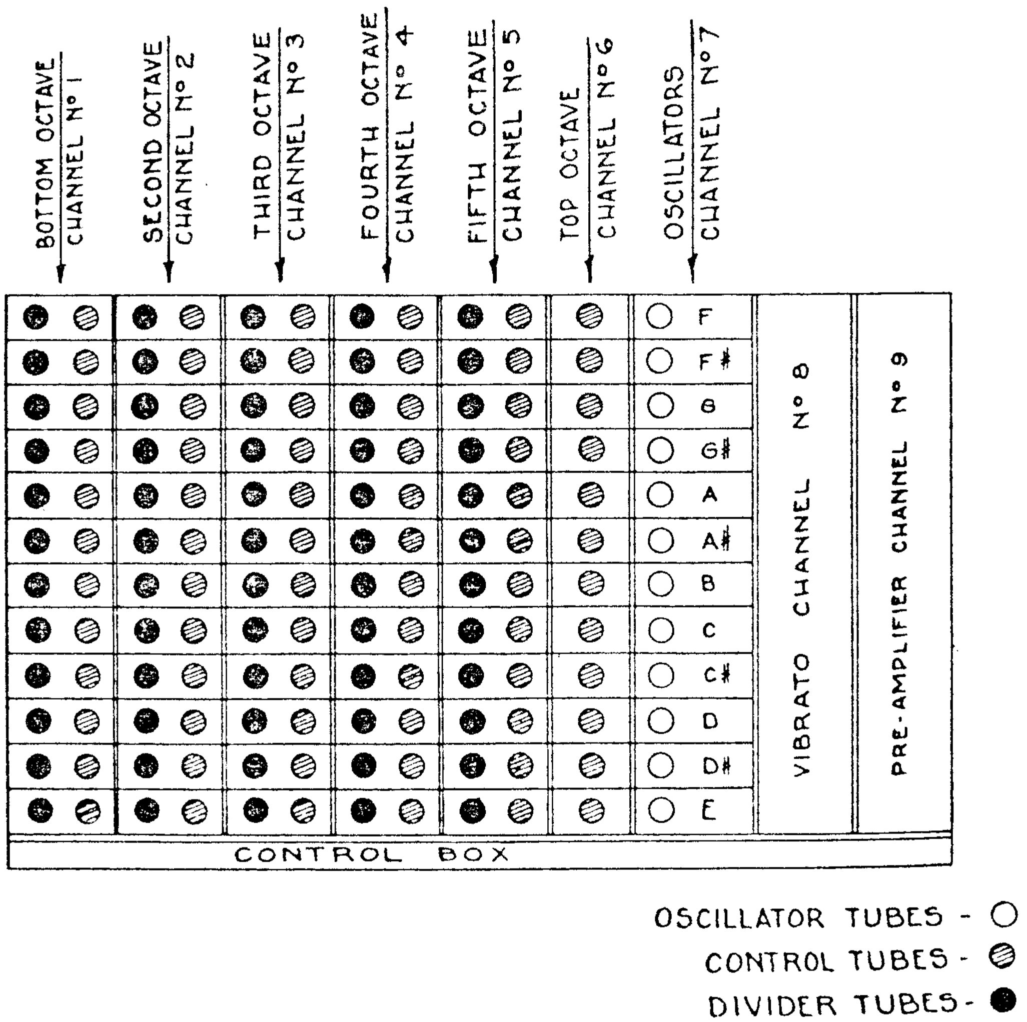
FIGURE 6

CONDENSER STOCK VALUES AND PAN NUMBERS

Pan No.	Capacity in MFD.	Pan No.	Capacity in MFD.	Pan No.	Capacity in MFD.
1	1.011 - .956	55	.0447 - .0423	109	.00198 - .00187
2	.955 - .902	56	.0422 - .0399	110	.00186 - .00177
3	.901 - .852	57	.0398 - .0377	111	.00176 - .00167
4	.851 - .804	58	.0376 - .0356	112	.00166 - .00158
5	.803 - .759	59	.0355 - .0336	113	.00157 - .00149
6	.758 - .716	60	.0335 - .0317	114	.00148 - .00141
7	.715 - .676	61	.0316 - .0299	115	.00140 - .00133
8	.675 - .638	62	.0298 - .0283	116	.00132 - .00125
9	.637 - .602	63	.0282 - .0267	117	.00124 - .00118
10	.601 - .569	64	.0266 - .0252	118	.00117 - .00112
11	.568 - .537	65	.0251 - .0238	119	.00111 - .001048
12	.536 - .507	66	.0237 - .0225	120	.001047 - .000989
13	.506 - .478	67	.0224 - .0212	121	.000988 - .000933
14	.477 - .452	68	.0211 - .0200	122	.000932 - .000881
15	.451 - .426	69	.0199 - .0189	123	.000880 - .000832
16	.425 - .402	70	.0188 - .0178	124	.000831 - .000785
17	.401 - .380	71	.0177 - .0168	125	.000784 - .000741
18	.379 - .359	72	.0167 - .0159	126	.000740 - .000699
19	.358 - .339	73	.0158 - .0150	127	.000698 - .000660
20	.338 - .320	74	.0149 - .0142	128	.000659 - .000623
21	.319 - .302	75	.0141 - .0134	129	.000622 - .000588
22	.301 - .285	76	.0133 - .0126	130	.000587 - .000555
23	.284 - .269	77	.0125 - .0119	131	.000554 - .000525
24	.268 - .254	78	.0118 - .0113	132	.000524 - .000495
25	.253 - .240	79	.0112 - .01056	133	.000494 - .000467
26	.239 - .226	80	.01055 - .00997	134	.000466 - .000440
27	.225 - .214	81	.00996 - .00941	135	.000439 - .000416
28	.213 - .202	82	.00940 - .00888	136	.000415 - .000393
29	.201 - .190	83	.00887 - .00838	137	.000392 - .000371
30	.189 - .180	84	.00837 - .00791	138	.000370 - .000350
31	.179 - .170	85	.00790 - .00747	139	.000349 - .000330
32	.169 - .160	86	.00746 - .00705	140	.000329 - .000313
33	.159 - .151	87	.00704 - .00665	141	.000312 - .000295
34	.150 - .143	88	.00664 - .00628	142	.000294 - .000278
35	.142 - .135	89	.00627 - .00593	143	.000277 - .000263
36	.134 - .127	90	.00592 - .00560	144	.000262 - .000248
37	.126 - .120	91	.00559 - .00528	145	.000247 - .000234
38	.119 - .114	92	.00527 - .00499	146	.000233 - .000222
39	.113 - .1064	93	.00498 - .00471	147	.000221 - .000209
40	.1063 - .1004	94	.00470 - .00444	148	.000208 - .000198
41	.1003 - .0948	95	.00443 - .00420	149	.000197 - .000186
42	.0947 - .0895	96	.00419 - .00396	150	.000185 - .000176
43	.0894 - .0845	97	.00395 - .00374	151	.000175 - .000166
44	.0844 - .0797	98	.00373 - .00353	152	.000165 - .000157
45	.0796 - .0753	99	.00352 - .00333	153	.000156 - .000148
46	.0752 - .0710	100	.00332 - .00315	154	.000147 - .000141
47	.0709 - .0671	101	.00314 - .00297	155	.000140 - .000133
48	.0670 - .0633	102	.00296 - .00280	156	.000132 - .000125
49	.0632 - .0598	103	.00279 - .00265	157	.000124 - .000118
50	.0597 - .0564	104	.00264 - .00250	158	.000117 - .000112
51	.0563 - .0533	105	.00249 - .00236	159	.000111 - .000104
52	.0532 - .0503	106	.00235 - .00223	160	.000103 - and below
53	.0502 - .0475	107	.00222 - .00210		
54	.0474 - .0448	108	.00209 - .00199		

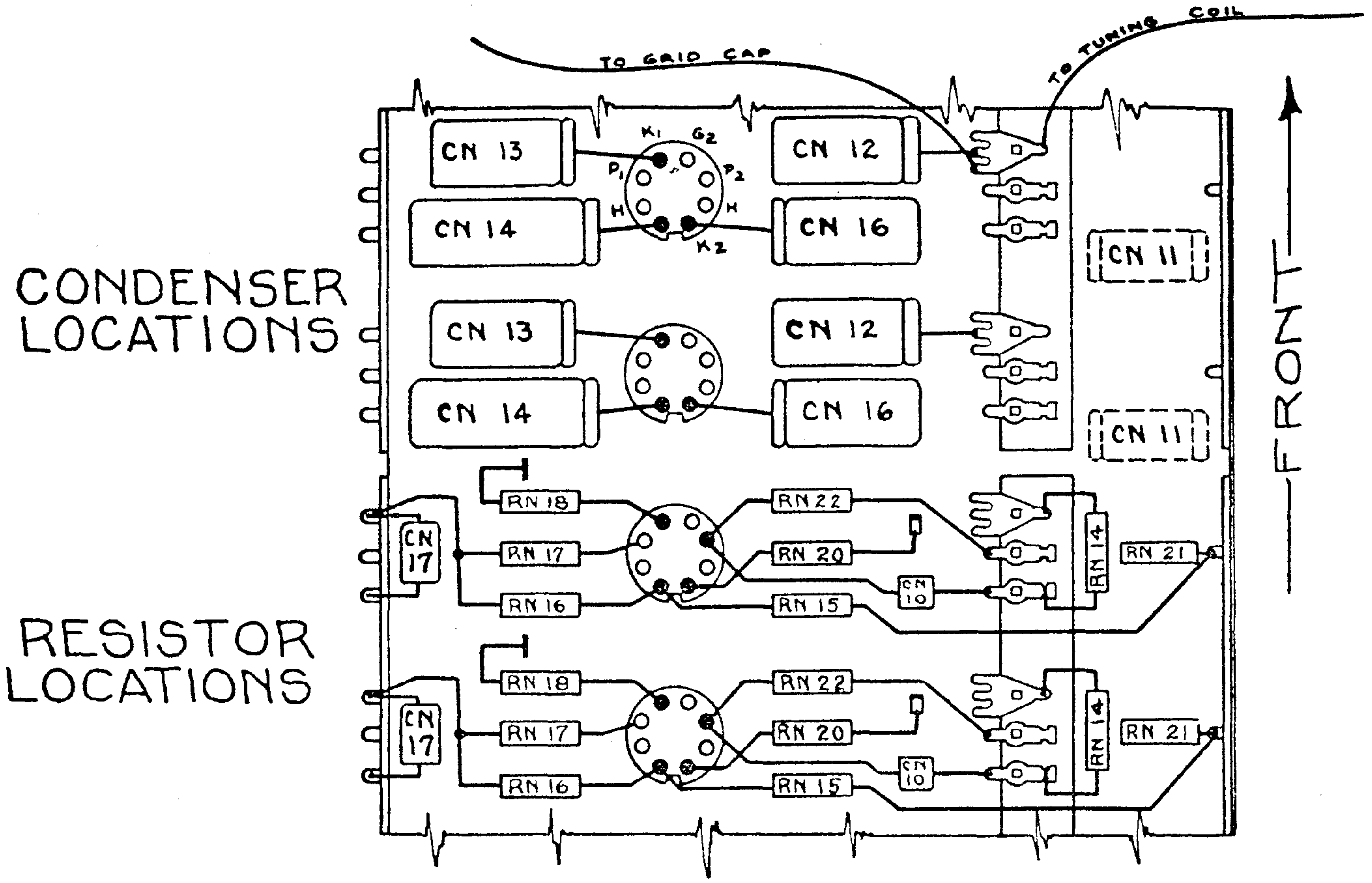
VALUE OF ADJUSTMENT RESISTOR								INSTALL RESISTOR	
NO RESISTOR	3.5 MEG.	3.0 MEG.	2.5 MEG.	2.0 MEG.	1.7 MEG.	1.5 MEG.	1.2 MEG.	CHANNELS 1,2&3	CHANNELS 4&5
OK	OK	OK	OK	OK	HIGH	HIGH	HIGH	3.5 MEG.	3 MEG.
OK	OK	OK	OK	OK	OK	HIGH	HIGH	3 "	2.5 "
OK	OK	OK	OK	OK	OK	OK	HIGH OR OK	2.5 "	2 "
LOW	OK	OK	OK	OK	OK	OK	OK	2 "	1.7 "
LOW	LOW	OK	OK	OK	OK	OK	OK	1.7 "	1.5 "
LOW	LOW	LOW	LOW OR OK	OK	OK	OK	OK	1.5 "	1.2 "

DIVIDER TUNING RESISTOR TABLE



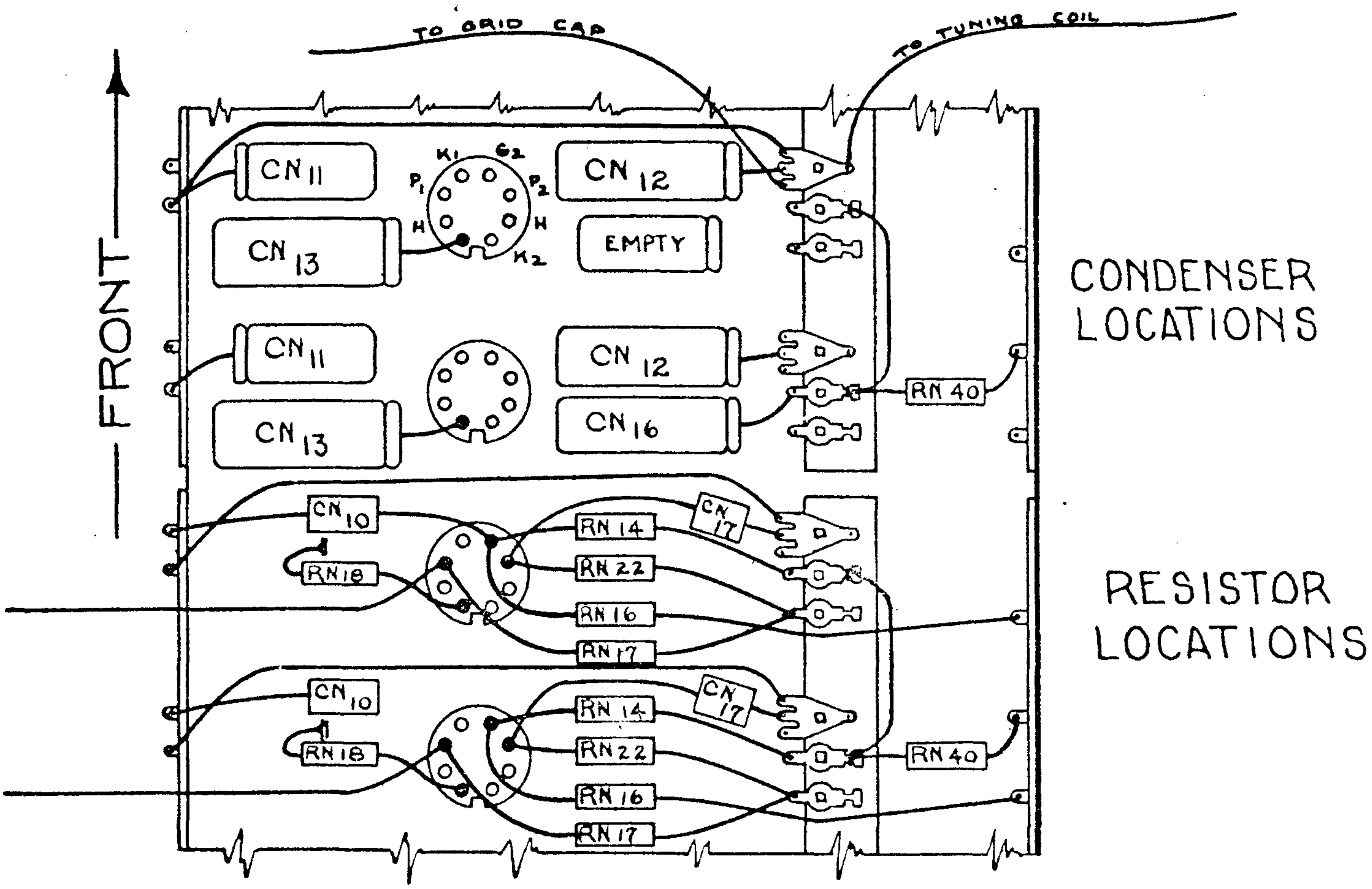
TOP VIEW OF GENERATOR

FIGURE 7



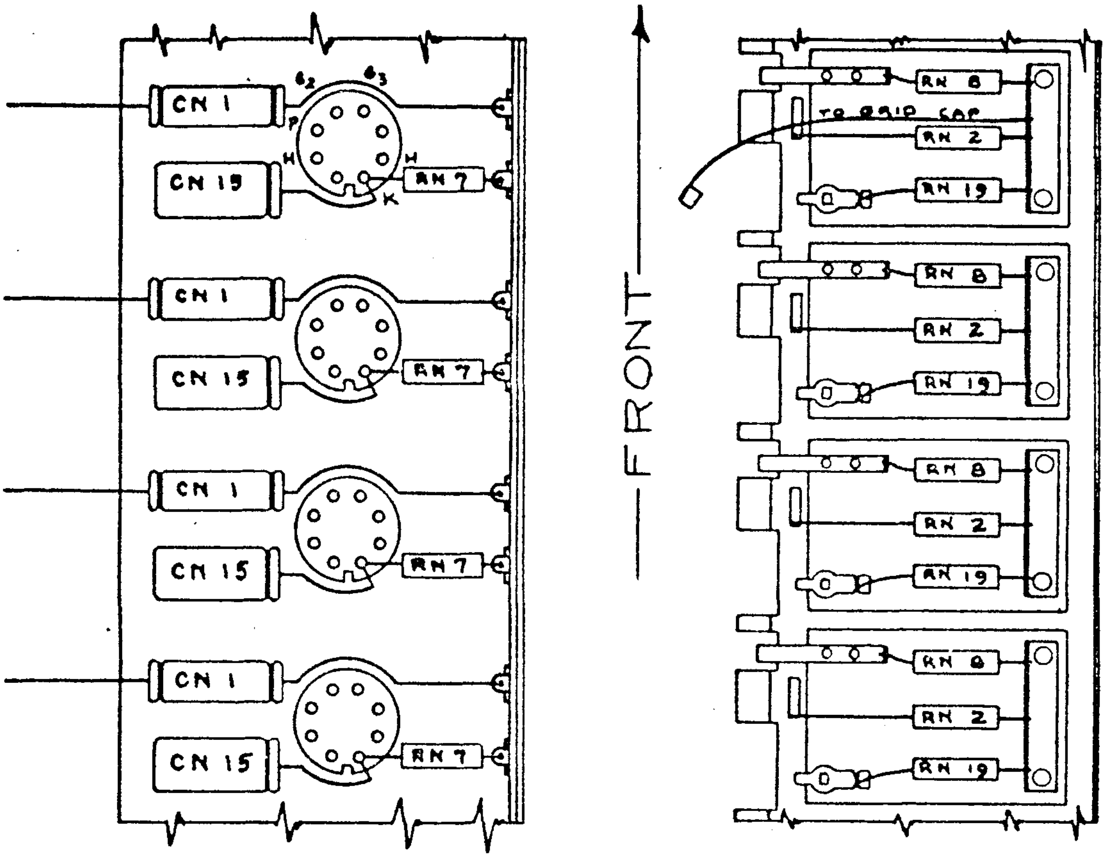
OSCILLATOR CHANNEL
NOVACHORD SERIAL NUMBER BELOW 1700
PARTIAL BOTTOM VIEW

FIGURE 8



OSCILLATOR CHANNEL
NOVACHORD SERIAL NUMBER 1700 & ABOVE
PARTIAL BOTTOM VIEW

FIGURE 9

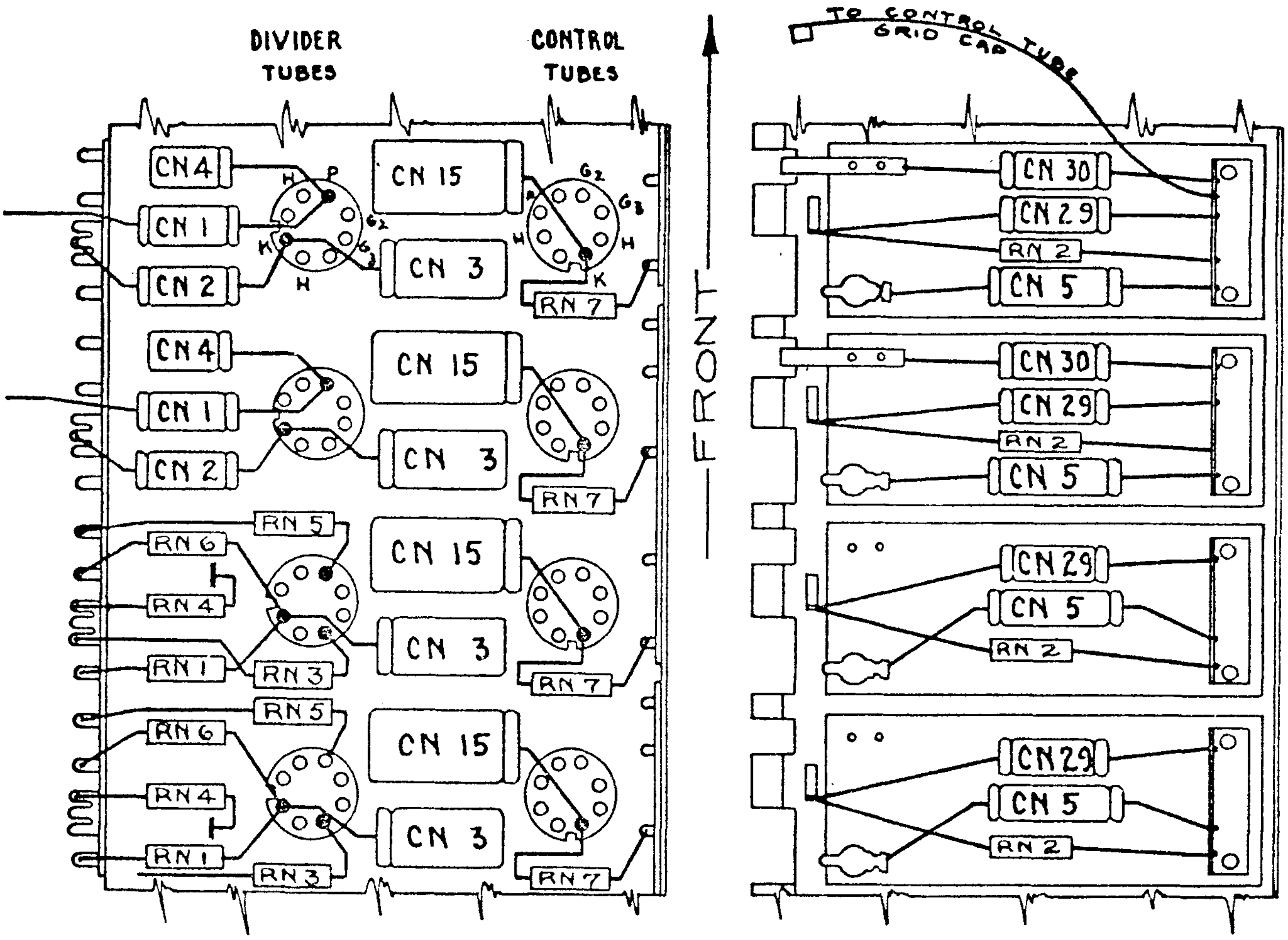


BOTTOM VIEW

INSIDE OF COVER

TOP OCTAVE CONTROL CHANNEL

FIGURE 10



BOTTOM VIEW

INSIDE OF COVER

TYPICAL DIVIDER & CONTROL CHANNEL
SHOWING CONDENSER AND RESISTOR LOCATIONS
FIGURE 11

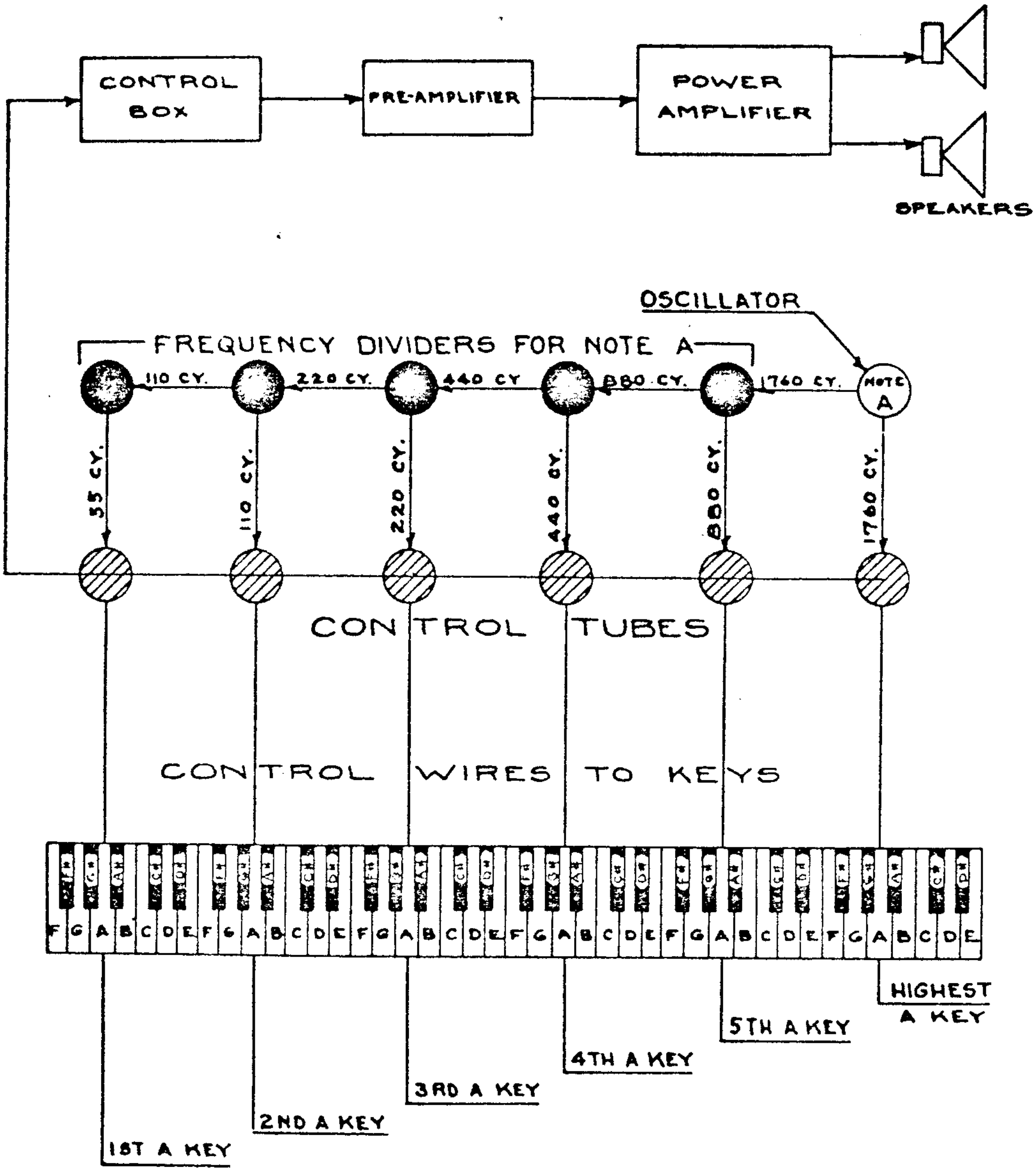
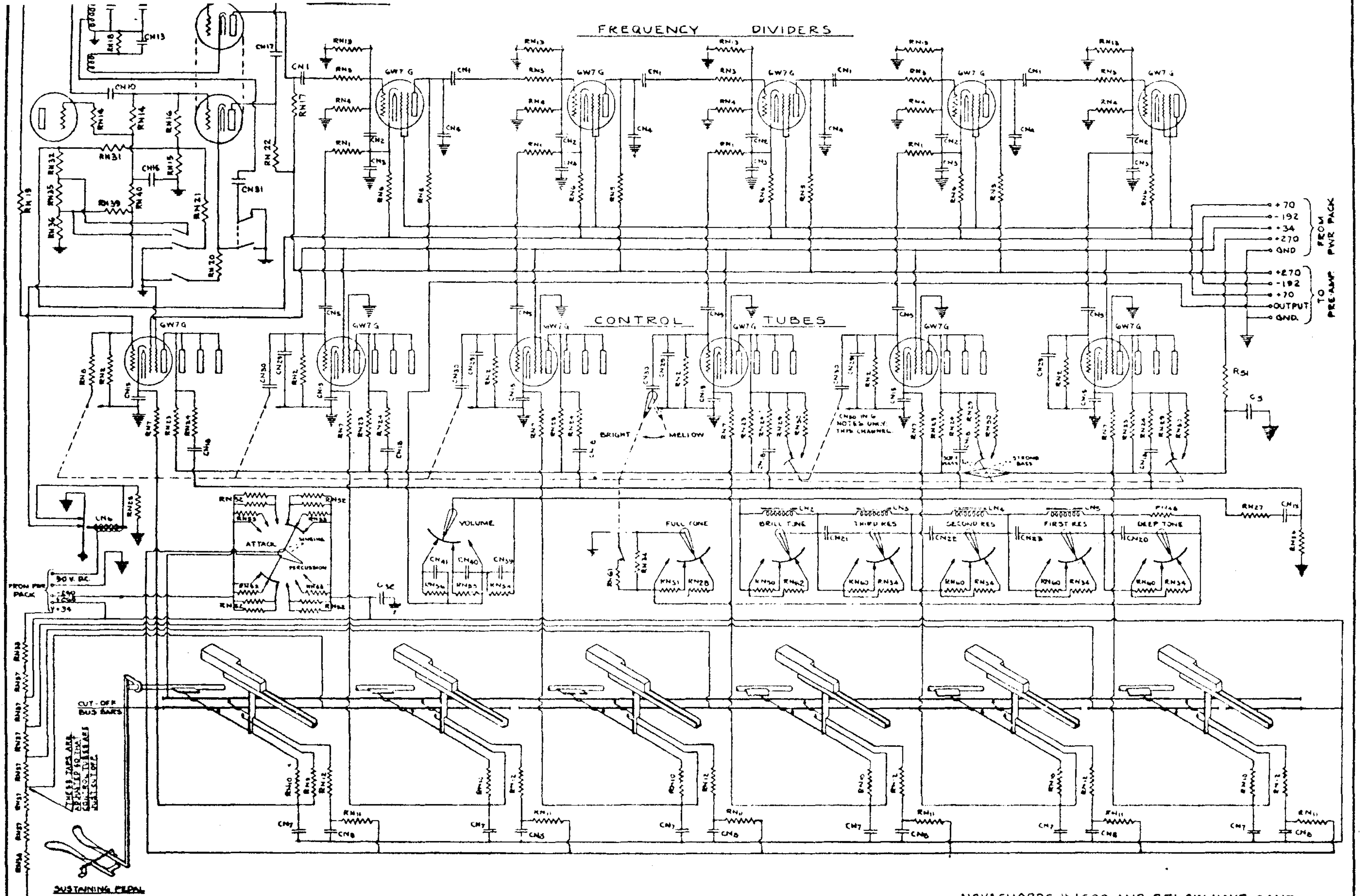

CONTROL BOX
PRE-AMPLIFIER
POWER AMPLIFIER
SPEAKERS
OSCILLATOR
FREQUENCY DIVIDERS FOR NOTE A
110 CY.
220 CY.
440 CY
880 CY.
1760 CY.
NOTE A
55 CY.
110 CY.
220 CY.
440 CY.
880 CY.
1760 CY.
CONTROL TUBES
CONTROL WIRES TO KEYS
1ST A KEY
2ND A KEY
3RD A KEY
4TH A KEY
5TH A KEY
HIGHEST A KEY

FIGURE 12

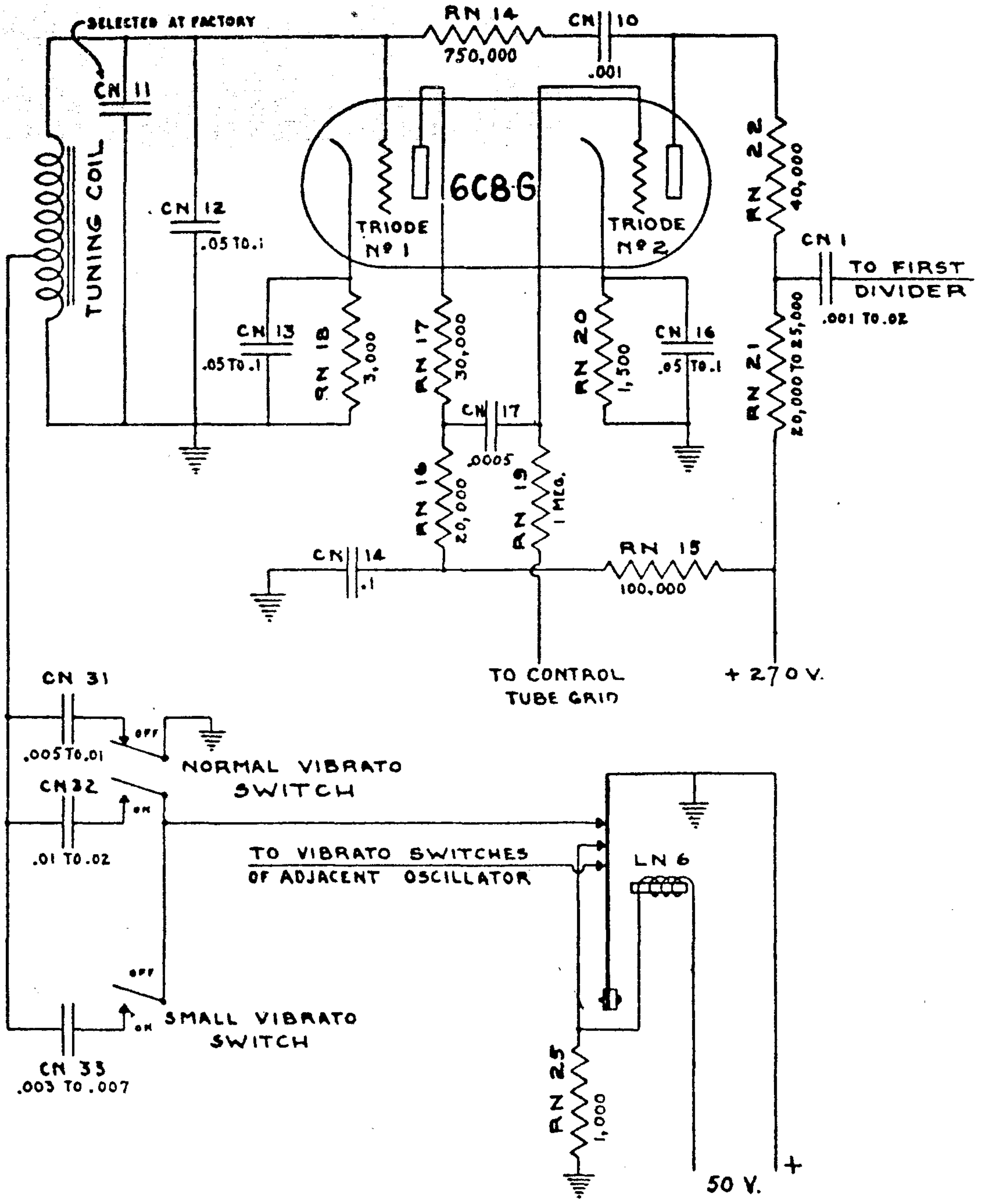


SCHEMATIC WIRING DIAGRAM
FIGURE 13

NOVACHORDS # 1699 AND BELOW HAVE SAME CIRCUIT EXCEPT OSCILLATOR

FOR NOVACHORD SER. # 1700 AND ABOVE

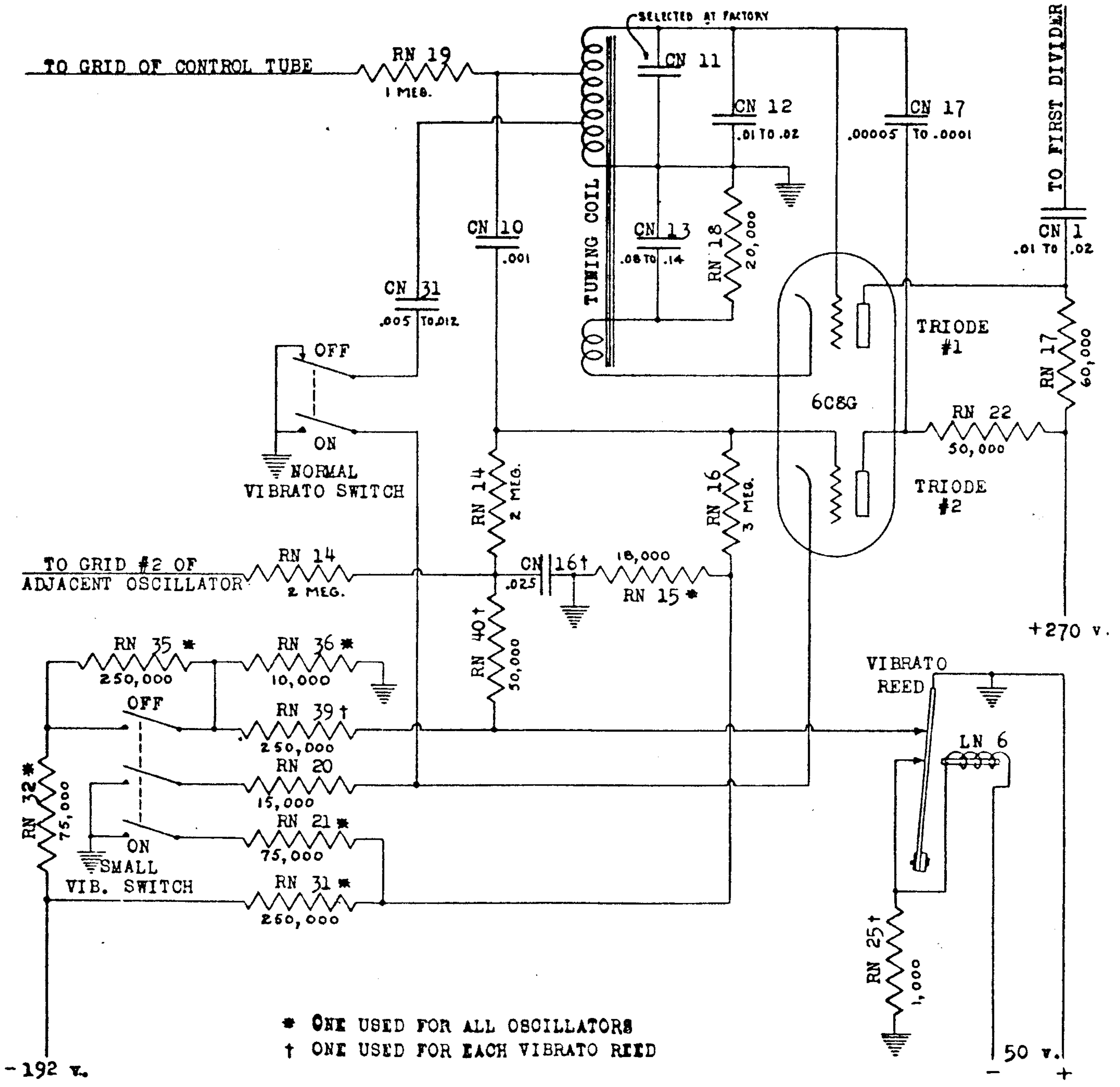
AO-17750-0



OSCILLATOR & VIBRATO CIRCUITS

NOVACHORDS SERIAL NUMBERED BELOW 1700

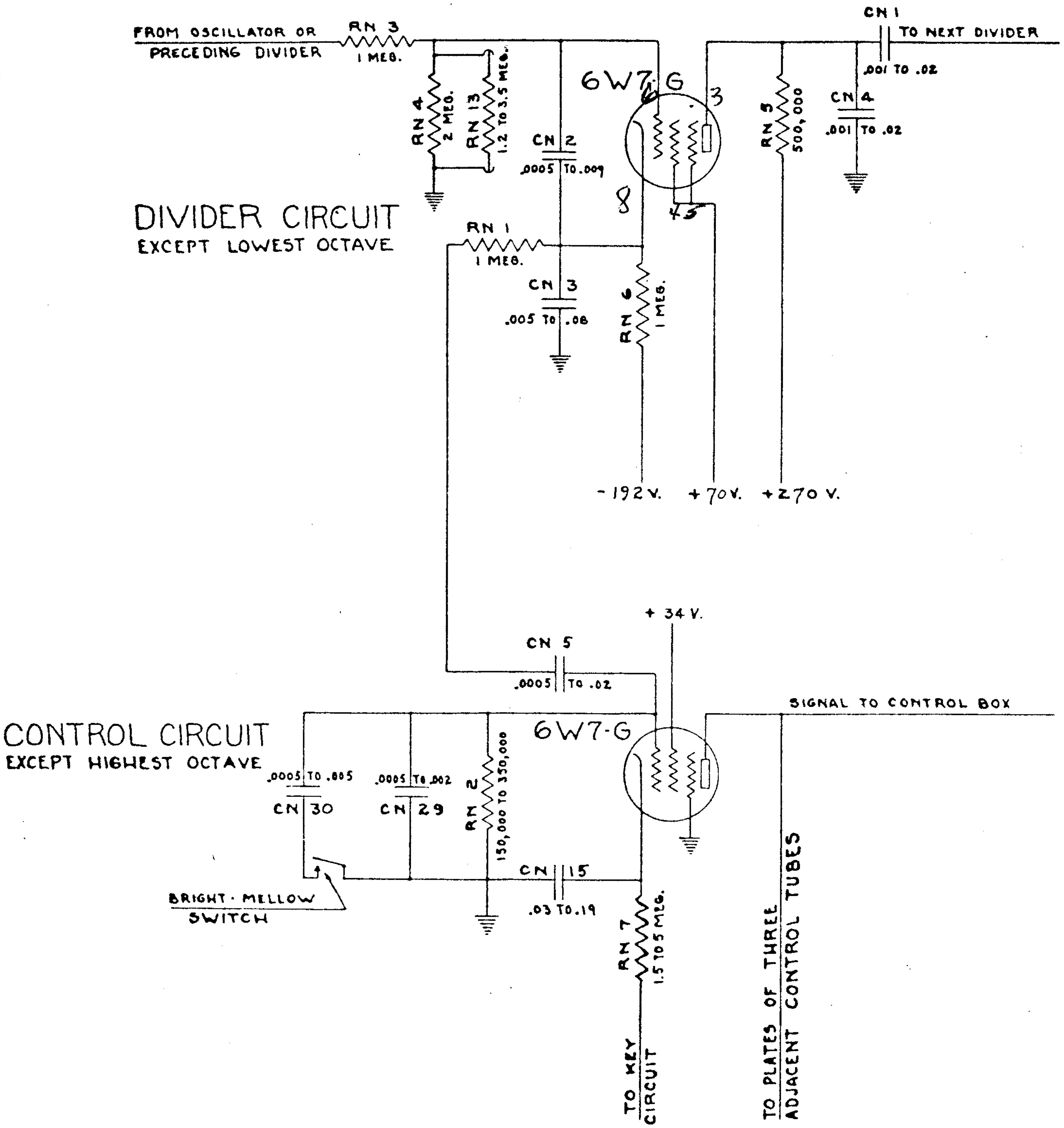
FIGURE 14



* ONE USED FOR ALL OSCILLATORS
† ONE USED FOR EACH VIBRATO REED

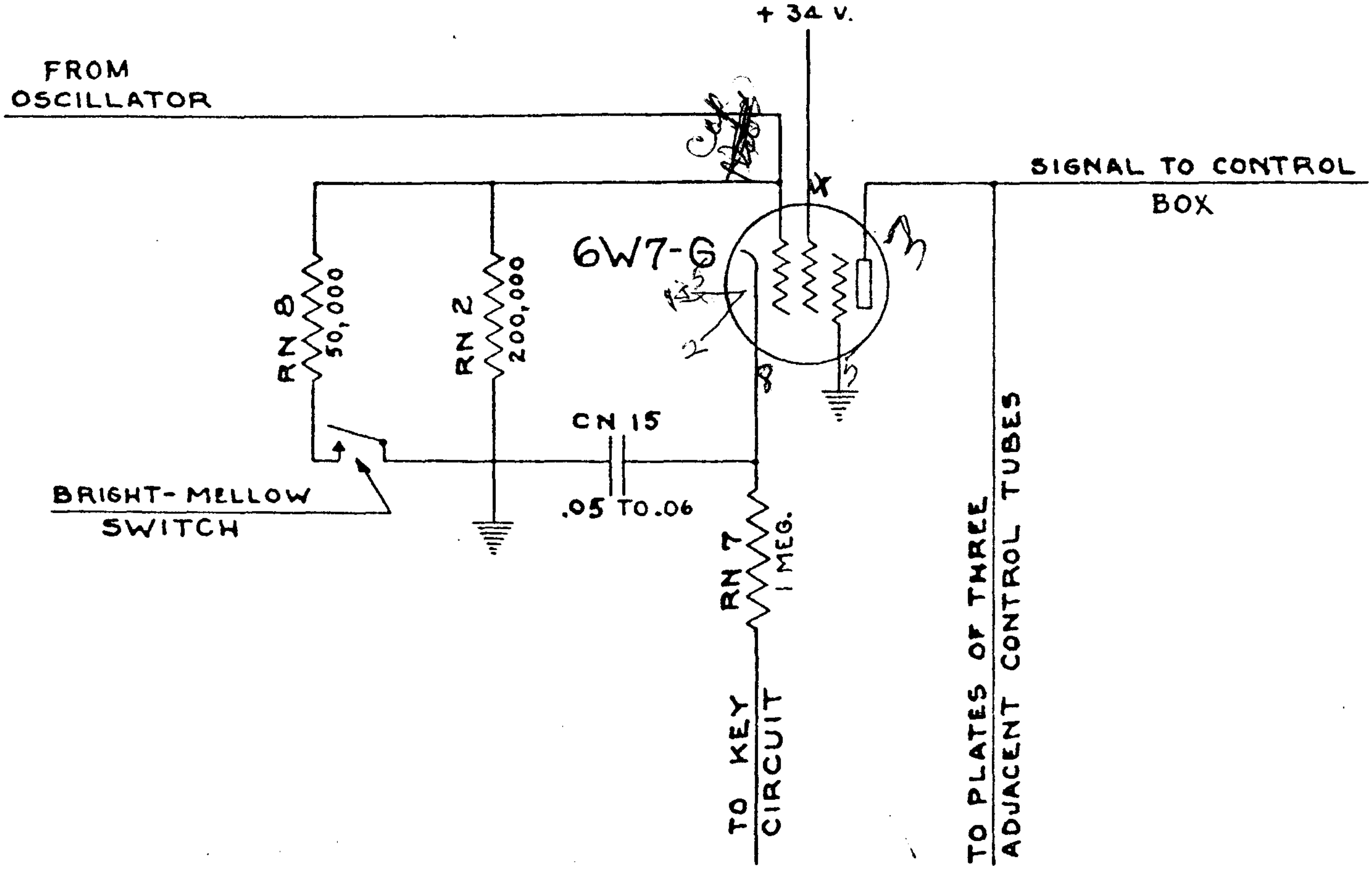
OSCILLATOR AND VIBRATO CIRCUIT
NOVACHORD SERIAL NO.1700 AND ABOVE

FIGURE 15



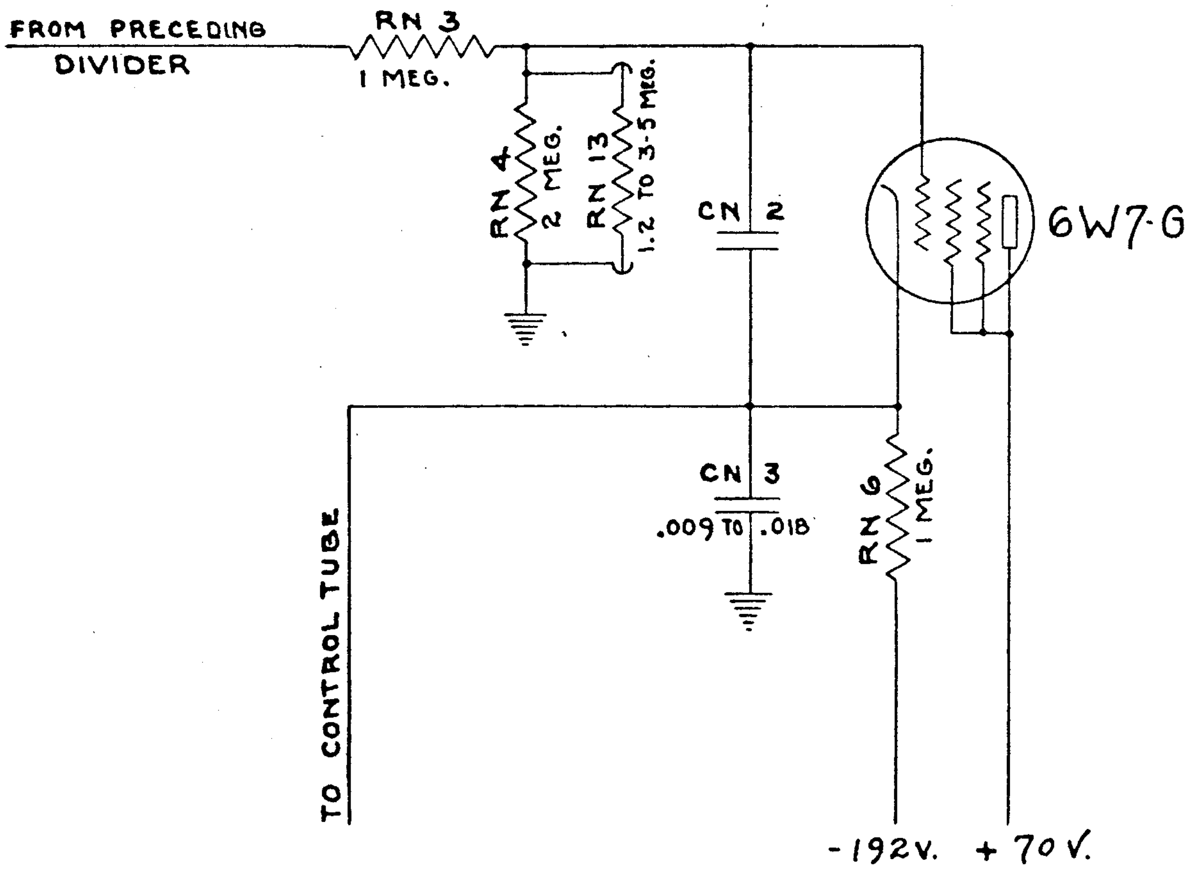
DIVIDER & CONTROL CIRCUITS

FIGURE 16



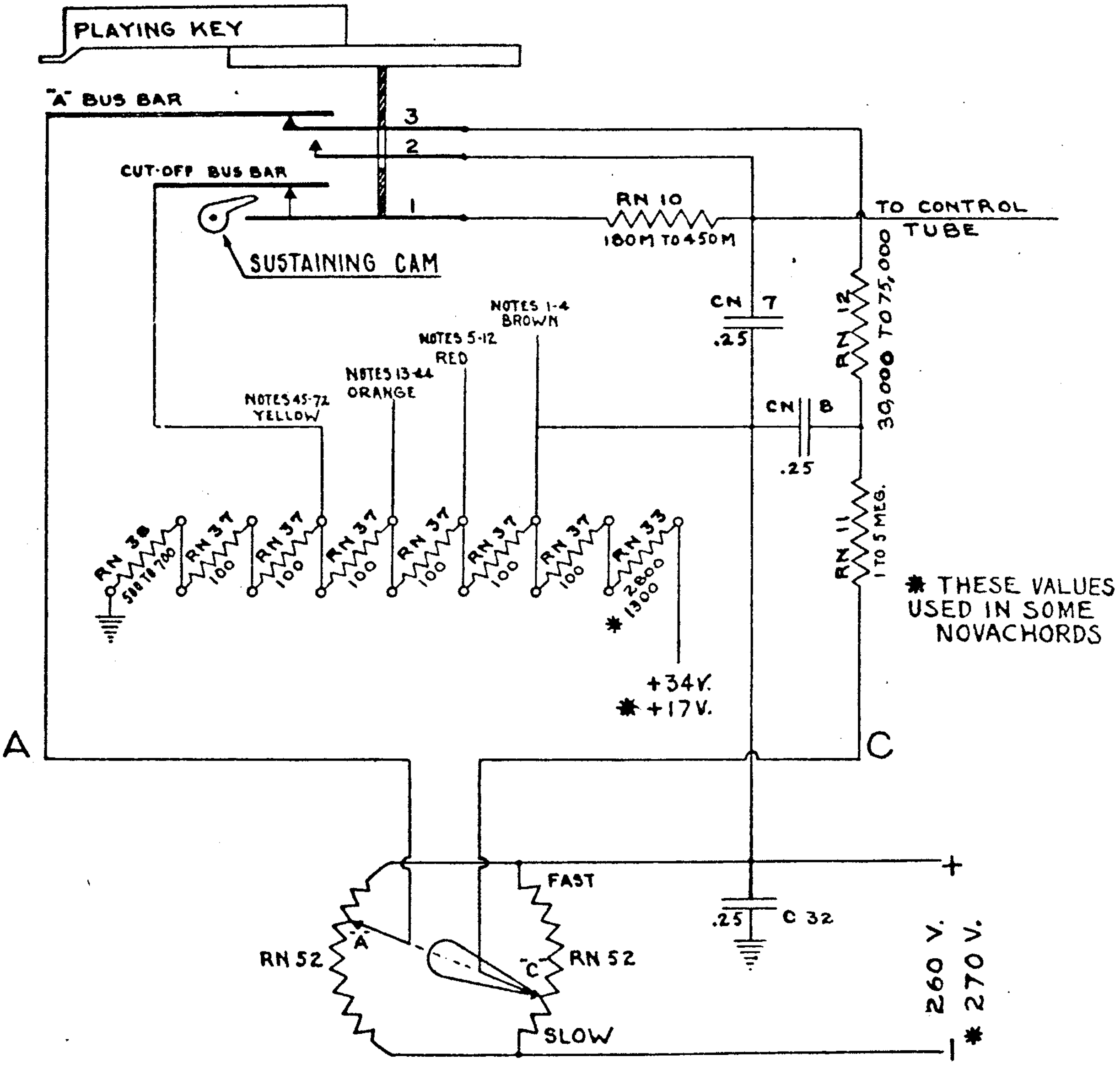
HIGHEST OCTAVE
CONTROL TUBE CIRCUIT

FIGURE 17



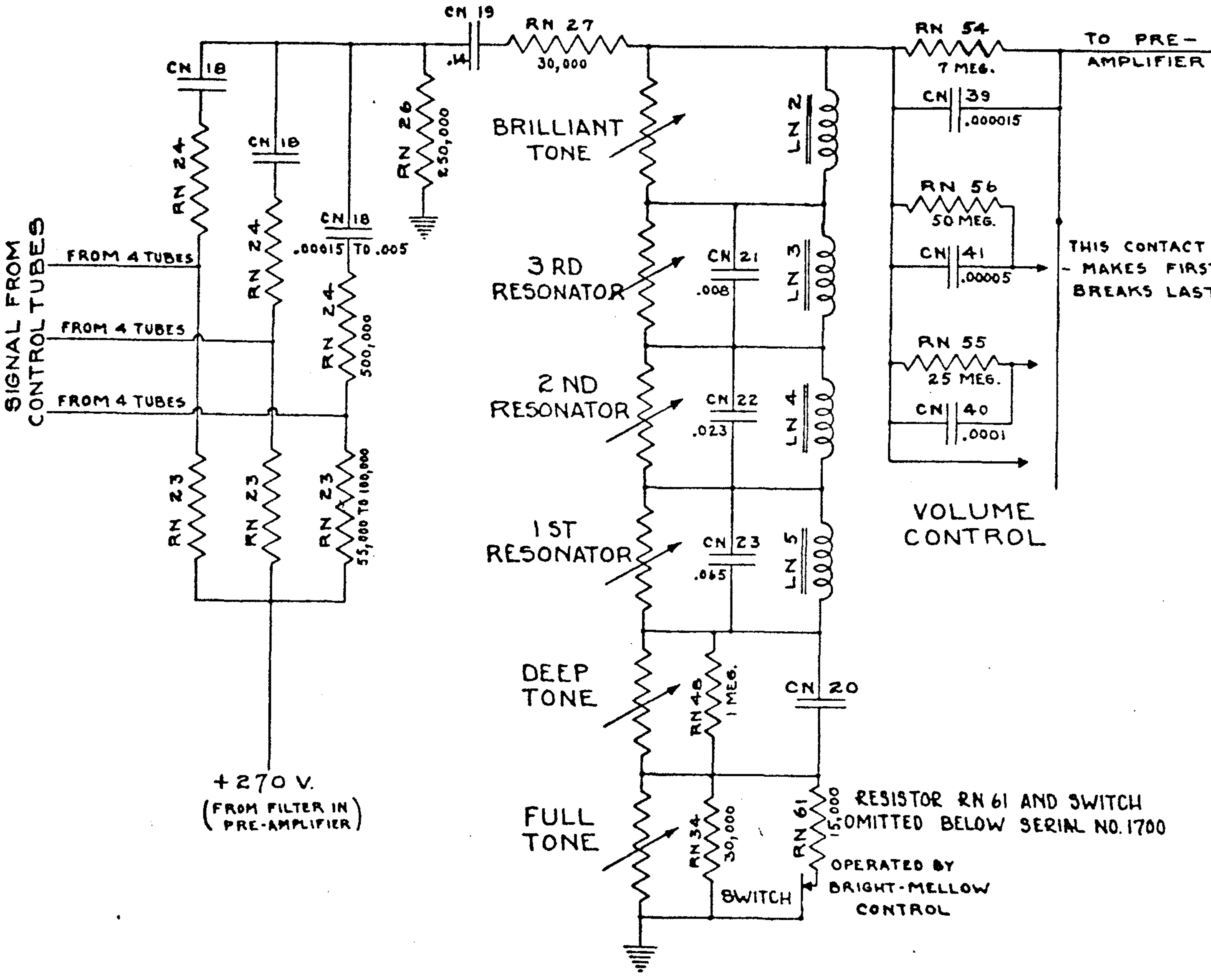
LOWEST OCTAVE
DIVIDER CIRCUIT

FIGURE 18



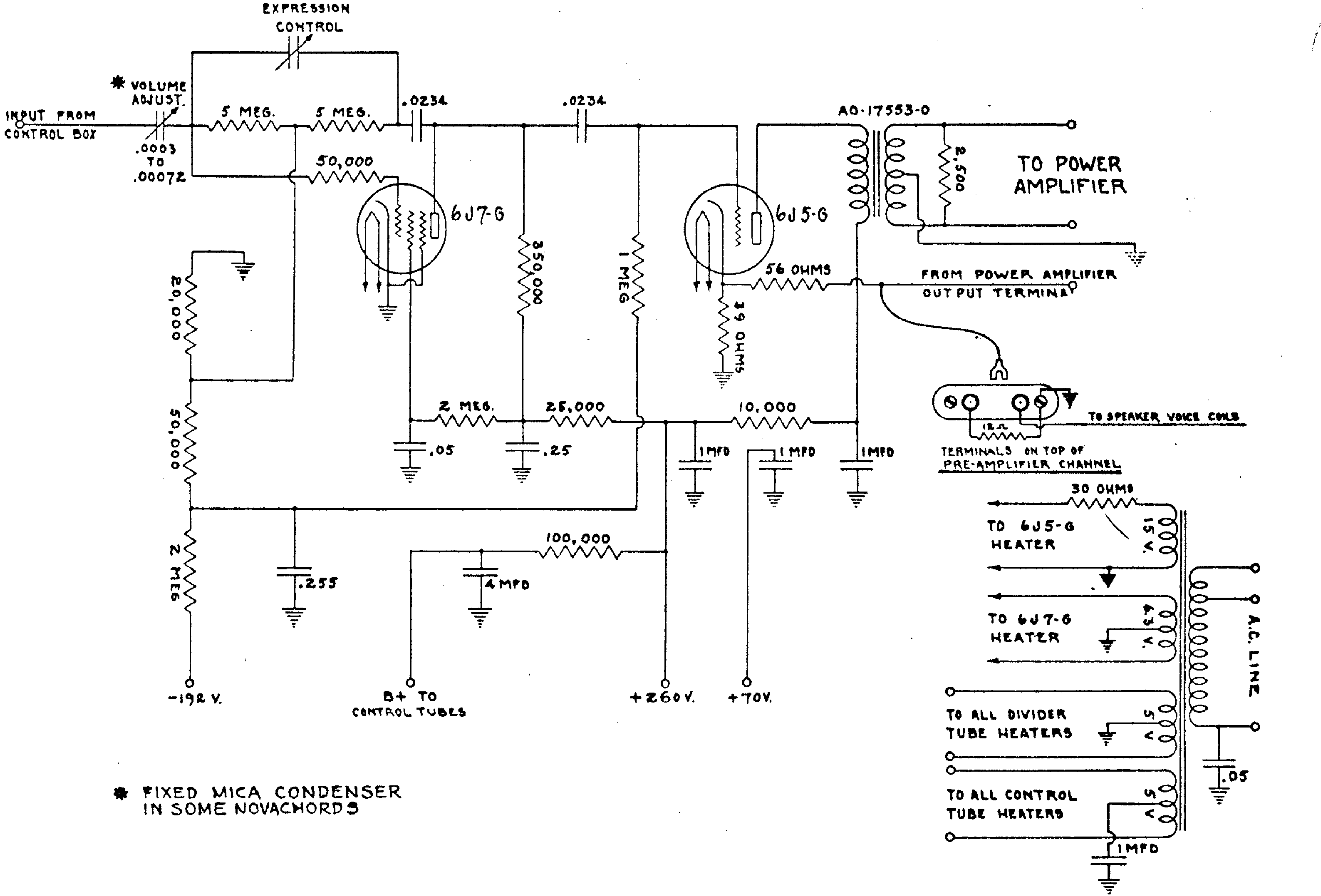
PLAYING KEY CIRCUIT

FIGURE 19



CONTROL BOX
SIGNAL CONNECTIONS

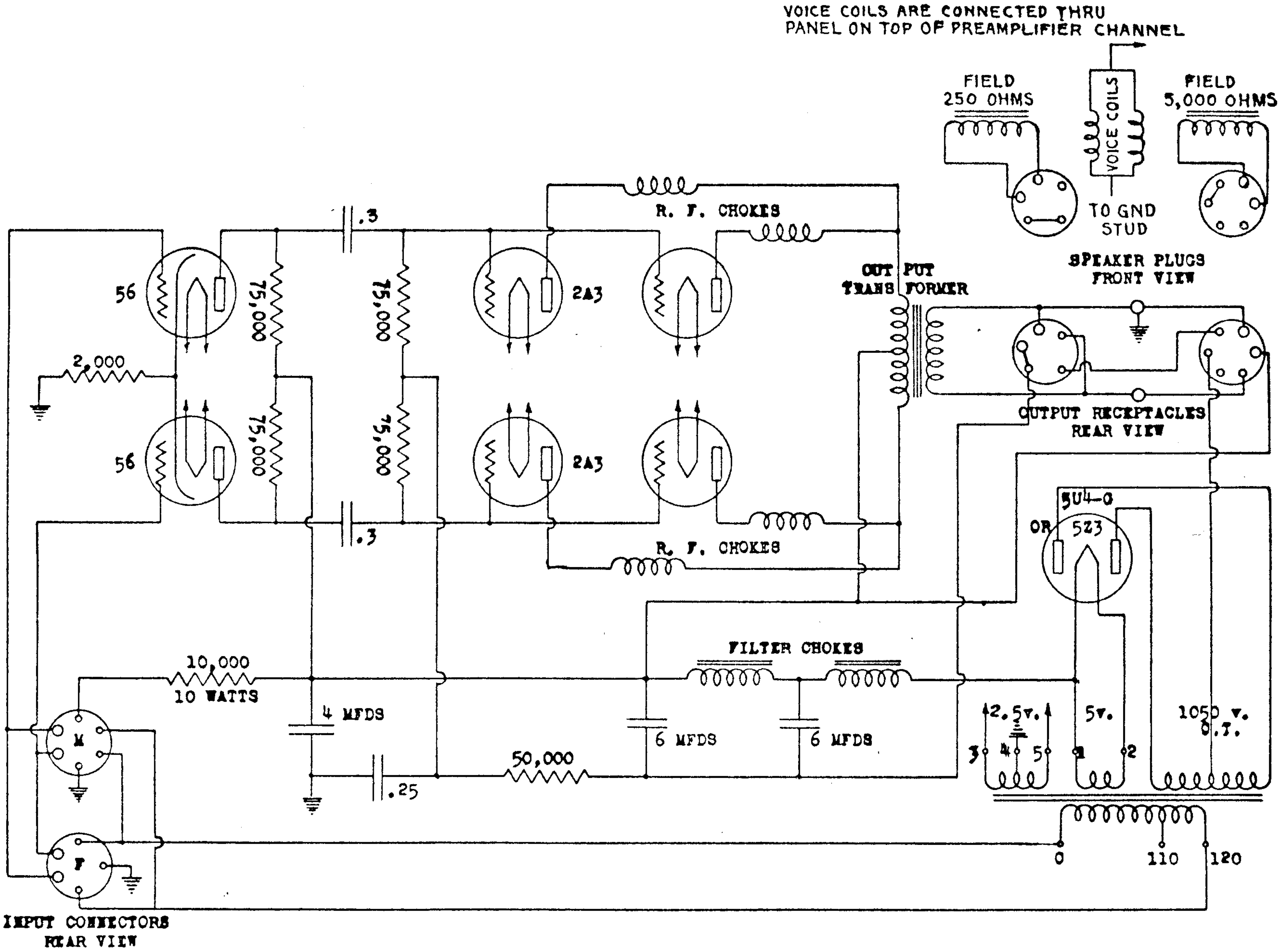
FIGURE 20



* FIXED MICA CONDENSER IN SOME NOVACHORDS

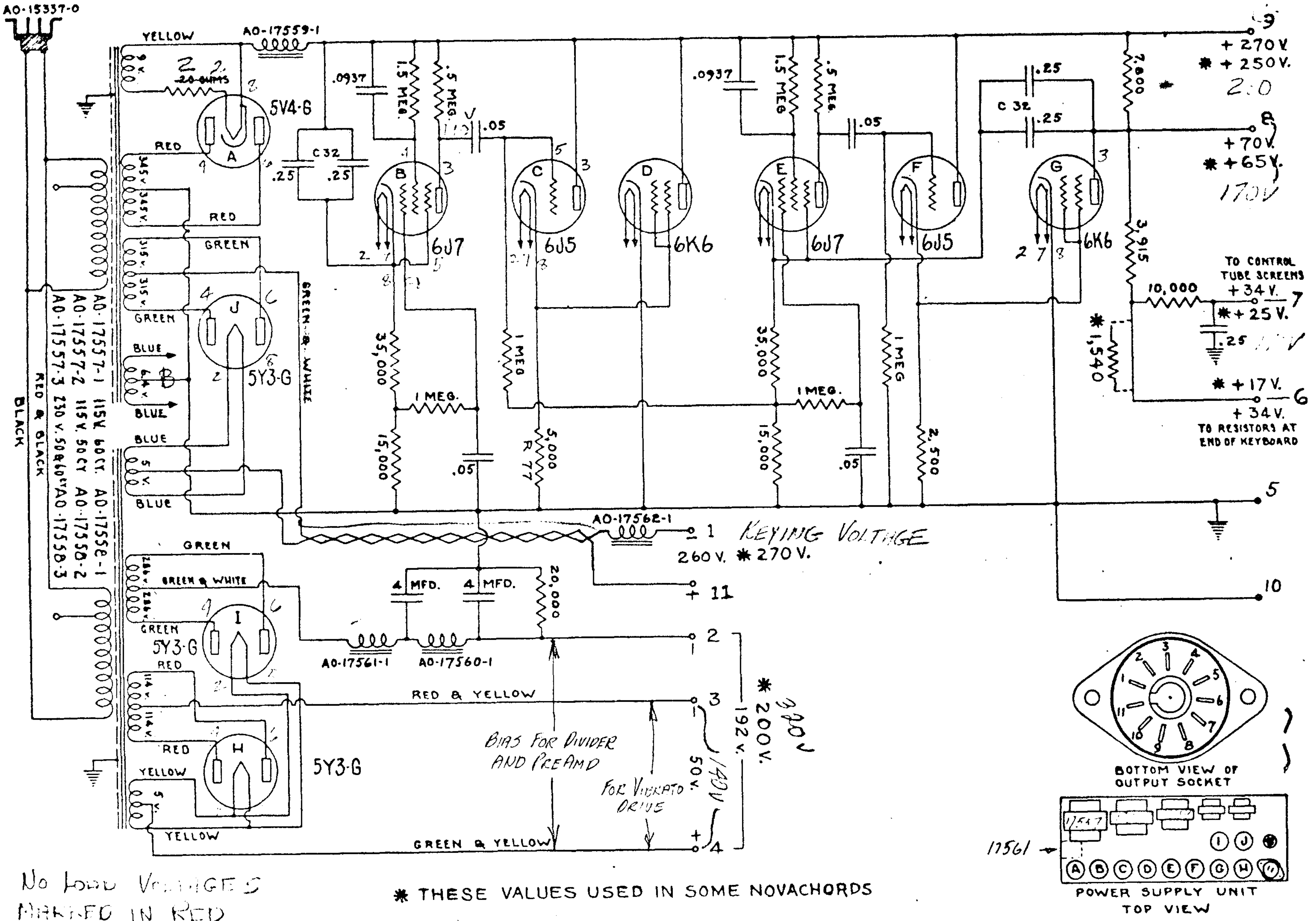
A0-17529-1	115 V. 60 CY.
A0-17529-2	115 V. 50 CY.
A0-17529-3	230 V. 50 & 60 C

PRE-AMPLIFIER
FIGURE 21


VOICE COILS ARE CONNECTED THRU PANEL ON TOP OF PREAMPLIFIER CHANNEL

POWER AMPLIFIER

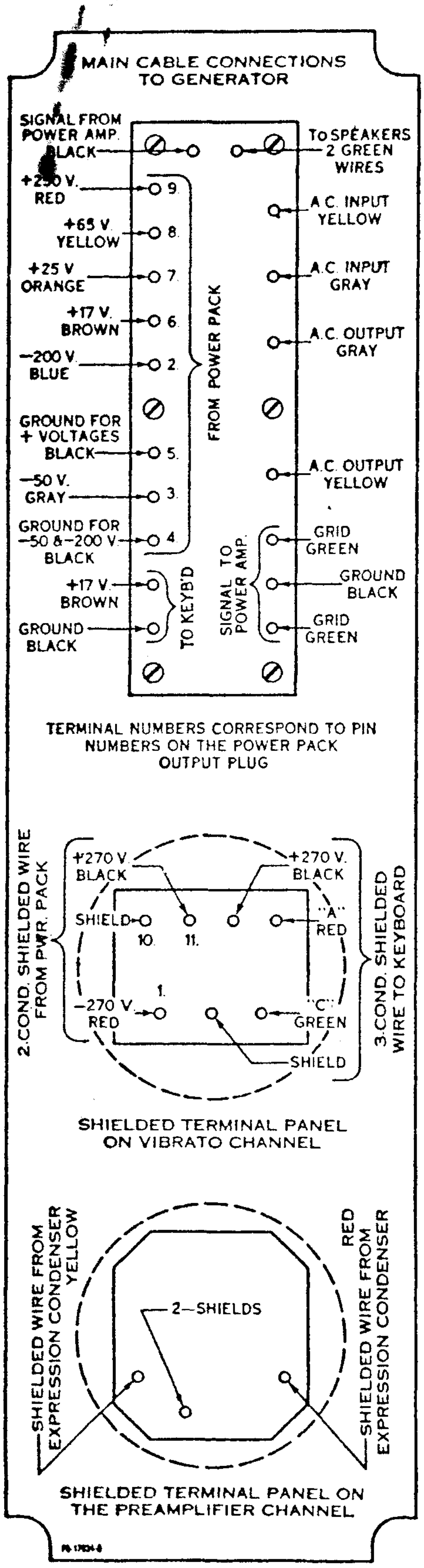
FIGURE 22



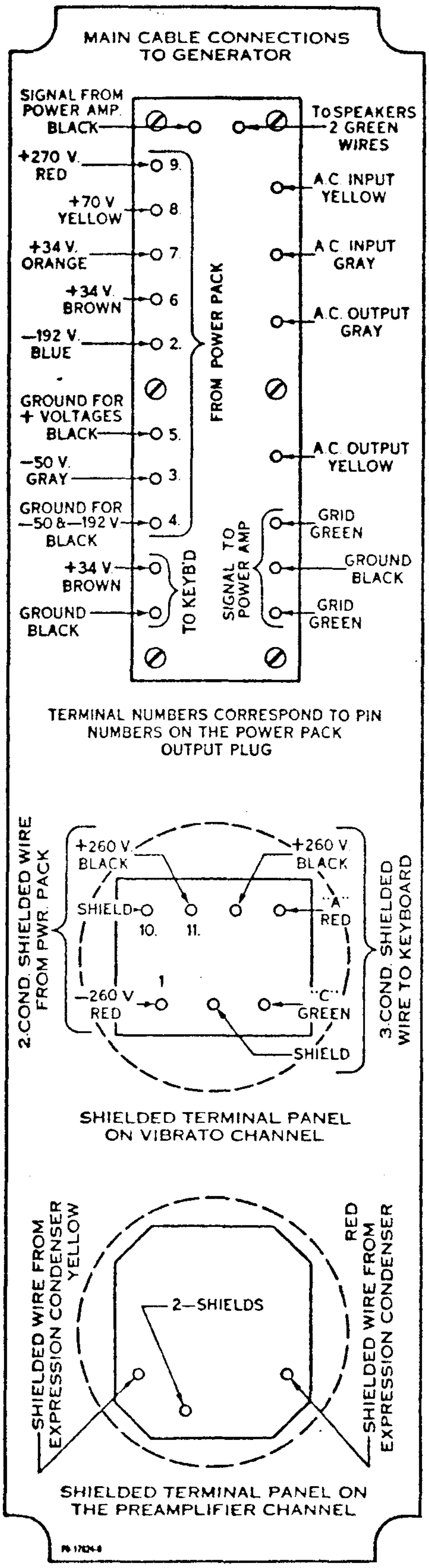
No Load Voltages Marked in Red

✱ THESE VALUES USED IN SOME NOVACHORDS

POWER SUPPLY UNIT

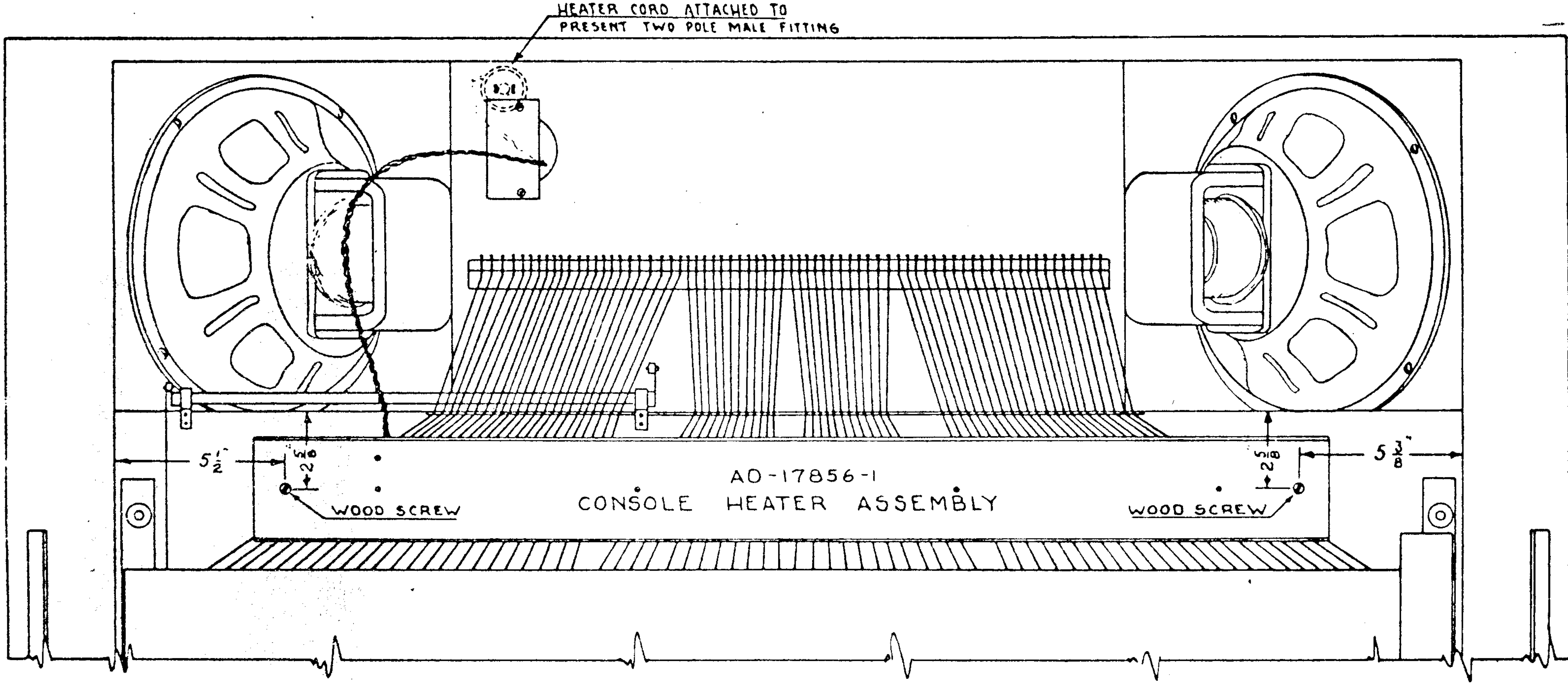

MAIN CABLE CONNECTIONS TO GENERATOR
SIGNAL FROM POWER AMP. BLACK
+250 V. RED
+65 V. YELLOW
+25 V ORANGE
+17 V. BROWN
−200 V. BLUE
GROUND FOR + VOLTAGES BLACK
−50 V. GRAY
GROUND FOR −50 & −200 V. BLACK
+17 V. BROWN
GROUND BLACK
9
8
7
6
2
5
3
4
FROM POWER PACK
TO KEYB'D
TO SPEAKERS 2 GREEN WIRES
A.C. INPUT YELLOW
A.C. INPUT GRAY
A.C. OUTPUT GRAY
A.C. OUTPUT YELLOW
SIGNAL TO POWER AMP.
GRID GREEN
GROUND BLACK
GRID GREEN
TERMINAL NUMBERS CORRESPOND TO PIN NUMBERS ON THE POWER PACK OUTPUT PLUG
2.COND. SHIELDED WIRE FROM PWR. PACK
+270 V. BLACK
+270 V. BLACK
SHIELD
10.
11.
"A" RED
1.
−270 V. RED
"C" GREEN
SHIELD
3.COND. SHIELDED WIRE TO KEYBOARD
SHIELDED TERMINAL PANEL ON VIBRATO CHANNEL
SHIELDED WIRE FROM EXPRESSION CONDENSER YELLOW
2—SHIELDS
SHIELDED WIRE FROM EXPRESSION CONDENSER RED
SHIELDED TERMINAL PANEL ON THE PREAMPLIFIER CHANNEL

USED IN EARLIER MODELS


MAIN CABLE CONNECTIONS TO GENERATOR
SIGNAL FROM POWER AMP. BLACK
+270 V. RED
+70 V YELLOW
+34 V. ORANGE
+34 V. BROWN
−192 V. BLUE
GROUND FOR + VOLTAGES BLACK
−50 V. GRAY
GROUND FOR −50 & −192 V. BLACK
+34 V. BROWN
GROUND BLACK
9
8
7
6
2
5
3
4
FROM POWER PACK
TO KEYB'D
TO SPEAKERS 2 GREEN WIRES
A.C. INPUT YELLOW
A.C. INPUT GRAY
A.C. OUTPUT GRAY
A.C. OUTPUT YELLOW
SIGNAL TO POWER AMP
GRID GREEN
GROUND BLACK
GRID GREEN
TERMINAL NUMBERS CORRESPOND TO PIN NUMBERS ON THE POWER PACK OUTPUT PLUG
2.COND. SHIELDED WIRE FROM PWR. PACK
+260 V. BLACK
+260 V. BLACK
SHIELD
10.
11.
"A" RED
1
−260 V. RED
"C" GREEN
SHIELD
3.COND. SHIELDED WIRE TO KEYBOARD
SHIELDED TERMINAL PANEL ON VIBRATO CHANNEL
SHIELDED WIRE FROM EXPRESSION CONDENSER YELLOW
2—SHIELDS
SHIELDED WIRE FROM EXPRESSION CONDENSER RED
SHIELDED TERMINAL PANEL ON THE PREAMPLIFIER CHANNEL

USED IN LATER MODELS

FIGURE 24



HEATER INSTALLATION IN NOVACHORD

FIGURE 25

NOVACHORD KIT #2. (revised)

AO-20290 Resistors - 1 each Total 42 at .11 each

VALUE

1,000 ohms
1,200
2,700
3,000
3,900
5,000 or 5,100
10,000
22,000
25,000
30,000
39,000
55,000
50,000
60,000

VALUE

68,000
82,000
87,000
100,000
110,000
150,000
180,000
200,000 or 220,000
330,000
390,000
470,000
500,000
600,000
750,000

VALUE

1 meg.
1
1.25
1.5
1.75
2
2.5
2.7
3
4
3
7
25
47

12 - PO-17358-0 Connecting Springs at .04 each

12 each of Pan #25 (may substitute #26, 27, or 28) at .87 each

1 each Double End Condensers No.'s 30 to 130 incl. Total 101 at .87 each

Pan #30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130

NOTE: Many resistors included in this kit differ slightly from the original equipment due to RMA code. Double end condensers also replace all single end formerly used.